technical note technical note

AD-A197 179

(2)

DTIC FILE COPY

LORAN C Offshore Flight Following (LOFF) in the Gulf of Mexico

Frank Lorge

February 1988

DOT/FAA/CT-TN88/8

U.S. Department of Transportation
Federal Aviation Administration

Technical Center
Atlantic City International Airport, N.J. 08405

NOTICE

Technical Report Documentation Page

1. Report No. DOT/FAA/CT-TN88/8	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle LORAN C OFFSHORE FLIGHT FOLLOWING (LOFF) IN THE GULF OF MEXICO		5. Report Date February 1988
		6. Performing Organization Code ACT-140
7. Author(s) Frank Lorge		8. Performing Organization Report No. DOT/FAA/CT-TN88/8
9. Performing Organization Name and Address Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. T0702K
12. Sponsoring Agency Name and Address Department of Transportation Federal Aviation Administration Program Engineering and Maintenance Service Washington, DC 20590		13. Type of Report and Period Covered Technical Note February 1988
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

The Federal Aviation Administration conducted simulation and flight tests on the Loran C Offshore Flight Following (LOFF) equipment installed in the Houston Air Route Traffic Control Center (ARTCC). Overall results of the LOFF test program were favorable. The system performs in a predictable and reasonable manner. Performance of the system is comparable to that of radar, although there is a slight difference in accuracy between the two.

17. Key Words Loran C Flight Following (LOFF) Gulf of Mexico Loran C Automatic Dependent Surveillance (ADS)	18. Distribution Statement This document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	68	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

EXECUTIVE SUMMARY

This report describes results of tests conducted by the Federal Aviation Administration (FAA) Technical Center to evaluate the Loran Offshore Flight Following (LOFF) system. Simulation and flight test were used to measure system performance under operational conditions.

The LOFF system is the first implementation of Automatic Dependent Surveillance (ADS) by the FAA to track aircraft. The system uses aircraft derived position as determined by Loran, transmitted by very high frequency (VHF) data link for use by air traffic controllers. A converter unit has been installed in the Houston Air Route Traffic Control Center (ARTCC) to process incoming LOFF messages and convert them into a radar data format. The results of this conversion are input to the Enhanced Direct Access Radar Channel (EDARC), which presents the aircraft as a conventional radar target. The system provides coverage in areas not currently served by radar, offshore in the Gulf of Mexico.

Simulated inputs were used during testing to determine accuracy of the LOFF converter, to measure timing delays, and to relate aircraft position in latitude longitude to a displayed position as seen by the controller. Flight tests were conducted to determine VHF coverage using the system, to measure Loran accuracy in the area, to compare dynamic performance with nondynamic performance of the EDARC system, and to provide an overall evaluation of the operational system.

Data reduction and analysis are described in the report, as well as an operational evaluation and identification of issues which must be addressed before full implementation of the system can take place.

Results showed that performance of the system differed from radar. However, these differences were fairly small and will not impact service in the offshore area where radar is not available. The LOFF system provides a benefit by tracking aircraft in an area where this service would otherwise be unavailable.

INTRODUCTION

This report describes a test conducted by the Federal Aviation Administration (FAA) Technical Center to evaluate the Loran Offshore Flight Following (LOFF) system and LOFF equipment currently installed in the Houston Air Route Traffic Control Center (ARTCC). The testing involved simulation of LOFF inputs and flight testing to quantify system performance under operational conditions.

The LOFF system is the first implementation of Automatic Dependent Surveillance (ADS) used by the FAA to track aircraft. Systems of this type use aircraft-derived position, transmitted over a data link, for display to an air traffic controller. Further development of systems of this type will provide air traffic control (ATC) automation and potentially reduce separation requirements in areas not currently served by radar.

The implementation of LOFF was undertaken by the FAA in order to serve the needs of offshore helicopter operators in the Gulf of Mexico. A large number of aircraft operate at low altitudes over the gulf, outside of radar coverage. Current Instrument Flight Rules (IFR) require manual (procedural) separation of aircraft based on very large separation criteria. Procedures require that blocks of airspace be reserved in which only one aircraft at a time is permitted. Traffic density in IFR conditions is, therefore, very low due to these large separation requirements.

LOFF uses a Loran navigational receiver to provide a position output which is transmitted over a very high frequency (VHF) data link using aircraft radios and existing remote communications facilities. A converter unit has been installed in the Houston ARTCC which converts the incoming LOFF message to radar message format. This message is then input to the Enhanced Direct Access Radar Channel (EDARC) where targets are tracked and prepared for display to controllers.

The primary purpose of the testing described in this report was to quantify the conversion accuracy of the LOFF equipment in the Houston ARTCC. Secondary objectives included gathering of operational data for use by Air Traffic organizations in developing separation standards and procedures for use of LOFF for ATC purposes.

Specific objectives were:

1. To measure conversion accuracy of the installed equipment relative to existing specifications for radar accuracy performance.

2. To determine the registration of latitude/longitude (lat/long) coordinates to system x-y coordinates as computed by EDARC.

3. To determine coverage limits of the system using existing FAA communications facilities offshore over the Gulf of Mexico.

4. To determine the relative performance of the LOFF system as compared to existing radar serving the areas in which coverage of the two systems overlap.

5. To measure accuracy of the Loran receivers currently approved for en route IFR use as required for the LOFF system.

6. To conduct an operational evaluation of the system in order to determine its suitability for use as an ATC tool.

BACKGROUND

LOFF is a concept developed primarily for use by offshore helicopter operators in the Gulf of Mexico. It is used for aircraft scheduling and position reporting. The FAA became interested in the system because of its potential to provide a cost-effective means of aircraft surveillance in areas not currently served by radar. The Houston ARTCC, which handles a large amount of helicopter traffic offshore, has a strong requirement for a system of this type.

Loran-C is a navigation system which uses low frequency transmission of timed, coded pulses to provide highly accurate position determination. Because Loran is not a line-of-site system, but is available over a large geographical area at all altitudes, it has become a very popular navigation system among helicopter operators. Helicopters are often required to operate in remote areas not served by conventional NAVAIDS. Loran is used in both the Visual Flight Rules (VFR) and IFR environments to provide en route navigation effectively and affordably.

The LOFF system as currently implemented utilizes existing offshore VHF communications facilities operated by the FAA for the transmission of LOFF data. Users must be equipped with an approved Loran receiver and an interface unit which converts position information into a LOFF message for transmission. The message is input to a standard aircraft VHF radio using voice frequencies assigned to the Houston ARTCC. A converter unit has been installed in the Houston Center which converts the LOFF data message into the same format as a conventional radar message. This message is sent to the EDARC, which processes it for display. A block diagram of the system is shown in figure 1.

Two types of Loran receivers are approved for en route use in the Gulf of Mexico. The TDL-711 receiver was first manufactured by Teledyne, Incorporated, in the mid-1970's. It is a single chain receiver which includes three Loran stations in its navigational solution. The ONI-7000, available from Offshore Navigation, Incorporated (also sold as the ANI-7000, from Advanced Navigation, Incorporated) can track as many as eight stations from up to four Loran chains simultaneously. This allows it to overcome some of the deficiencies of single-chain receivers. This receiver is not as susceptible to baseline extension errors and is usable throughout a larger service area because of its use of multiple chains.

The LOFF message consists of aircraft position data in lat/long aircraft altitude as input by the pilot or encoding altimeter, LOFF code (similar to radar beacon code), and update rate code. The format of the message is shown in table 1. Message data are encoded using the American Standard Code for Information Interchange (ASCII), transmitted at 1200 baud.

The LOFF concept has been developed and is in use by several operators to satisfy their own requirements. Commercially available hardware is available for both the aircraft installation and ground based display. Also, a large number of operators exist in the gulf who are currently equipped with Loran-C receivers.

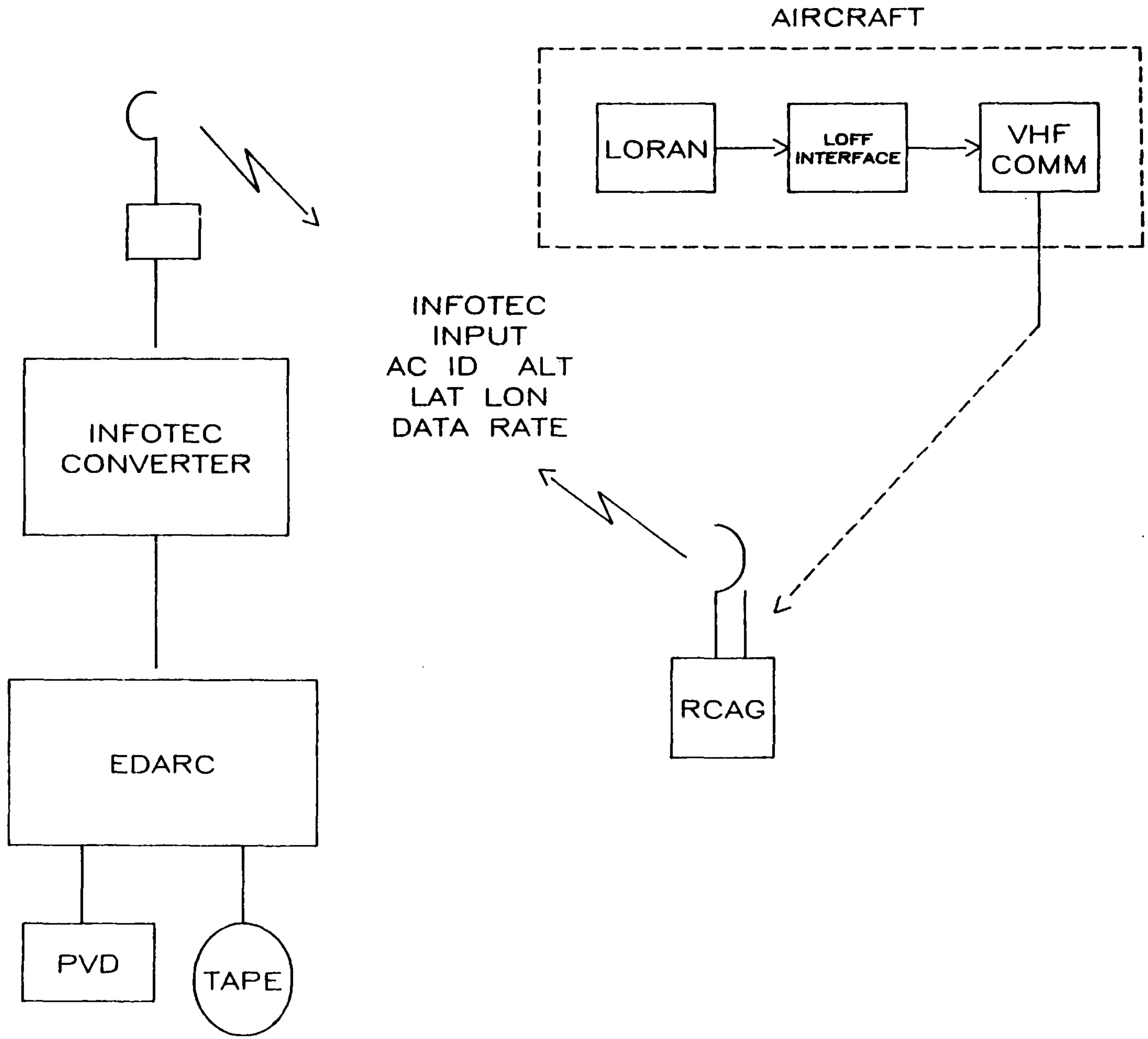

FIGURE 1. LOFF BLOCK DIAGRAM

TABLE 1. LOFF DATA MESSAGE

Character Number	Data Description
1	Begin Message Character (>)
2-4	Helicopter Identifier (ID) Code
5	Repetition Rate
6	Status Word*
7-12	Loran C Derived Latitude
13-18	Loran C Derived Longitude
19-21	Reported Altitude
22	End Message Character (})

*Status Word

Bit Number	Bit Value Description	
0	Both bits are (0) for normal transmission, or (1) for manual/emergency mode	
2	(0) for TD mode, (1) for lat/long mode	
3	Master	
4	Secondary A	(0) for Float
5	Secondary B	(1) for Track
6	Reported Altitude	(0) for Manual Entry (1) for Encoding Altimeter
7	(ODD) Parity bit	

Many of these also have LOFF equipment in their aircraft. The only new equipment required to complete the system was a converter unit in the ARTCC which would be compatible with existing ATC display equipment. The FAA contracted Infotec Development Corporation to design and build a converter unit which would accept the LOFF message from existing communications channels, convert the Loran position data to a radar format, and provide the converted data for input to existing radar channels.

EDARC.

The EDARC is a system developed as a backup to the National Airspace System (NAS) primary ATC computer system. It consists of processors and software which provide aircraft tracking, flight plan storage, and target display information for use in the event of a failure of the primary system.

The EDARC display appears very similar to that of the primary system, although its capabilities are much more limited. The radar input conversion and target tracking capabilities are also very similar to the primary system. EDARC was selected for use with the LOFF system because of its availability for testing and operations which coincided with the implementation of the NAS computer replacement program.

The system accepts inputs from NAS radar equipment and converts them into x-y coordinates in the geometric system plane. This plane is arbitrarily defined to be tangent to the earth at a fixed point. Distances from the tangent point are calculated from stereographic projections of aircraft position and displayed to controllers. The x coordinate corresponds to local east at the tangent point, and the y-coordinate corresponds to local north.

EDARC tracks each aircraft using a pair of alpha-beta trackers. Independent trackers run in the x and y coordinates of the system plane.

LOFF SECTOR.

The LOFF sector is shown in figure 2. The area extends roughly from 27°30' to 29° of latitude and 90° to 96° of longitude. The sector extends vertically from the surface to 5000 feet mean sea level (m.s.l). The shaded portion near Houston is an exclusion area in which the TDL-711 Loran receiver is not certified. Coverage is provided throughout the sector from the Southest U.S. Loran chain.

There are four sites which receive LOFF transmissions and send them to the Houston Center. These are at Galveston, Texas (GLSA), Intracoastal City, Louisiana (QIC), and on offshore oil rigs in the High Island (QHI) and Vermillion (QVM) areas of the gulf.

DATA COLLECTION

Data collection was conducted in two parts: simulation and flight test. Simulation was used, where possible, in order to fully test the system in the most economical manner. The LOFF system, in particular, lends itself to this type of testing because there are a finite number of possible inputs to the

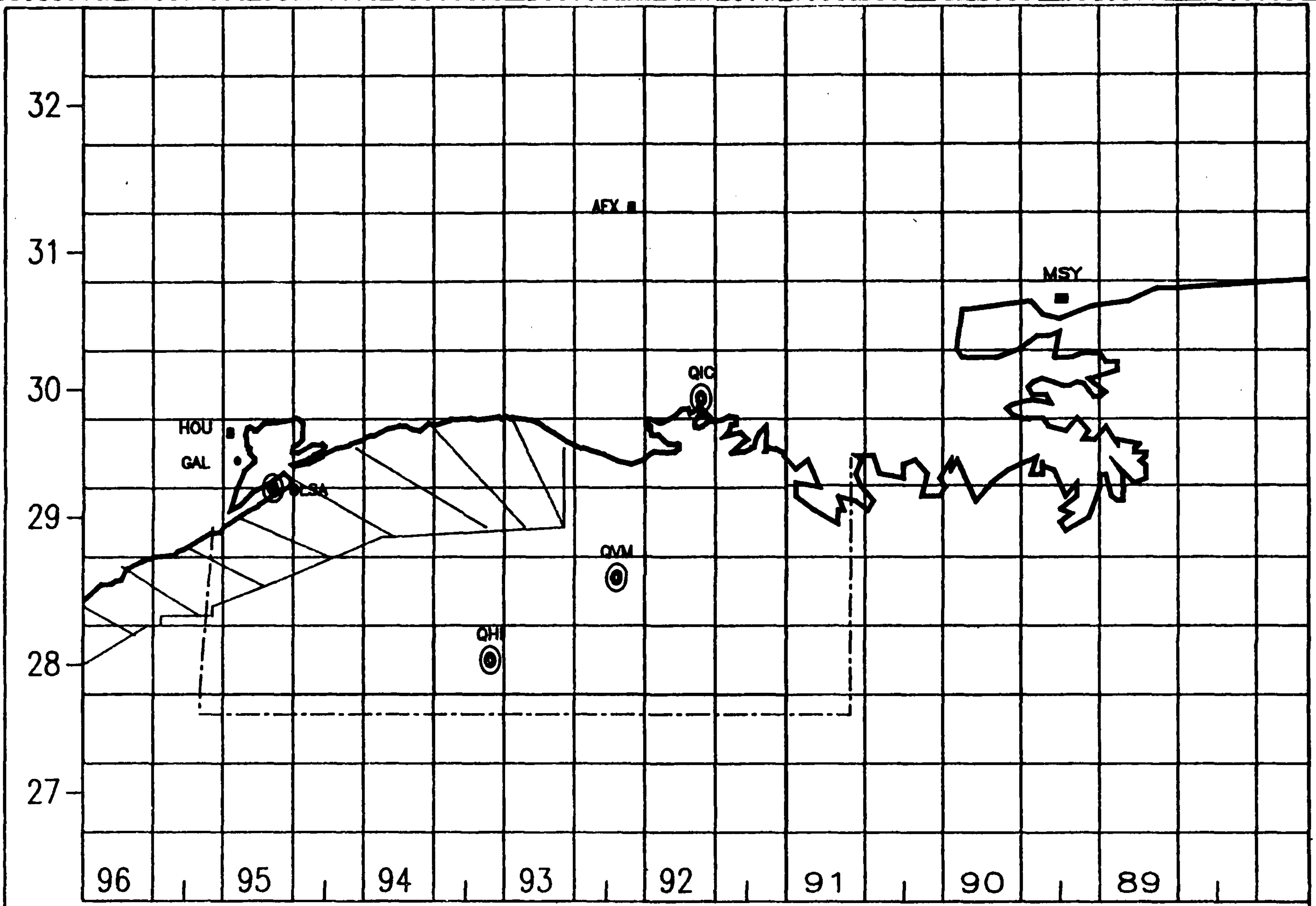

FIGURE 2. LOFF SECTOR

system. Flights were conducted to determine the limits of coverage of the existing communications facilities using LOFF equipment, to verify simulation results, to measure Loran accuracy, and to determine relative performance in radar-LOFF overlap areas.

SIMULATION.

The LOFF message is fairly easy to simulate with a low rate serial data line driven by computer. This procedure allows extensive testing in a reasonable time, as well as providing a means of isolating the converter from all other components of the system.

The test procedure was described in Technical Note DOT/FAA/CT-TN86/17 published in June 1986. The test was modified slightly during EDARC testing due to the difficulties associated with equipment scheduling in the operational environment of the Houston Center. The original test procedure was intended to collect data to determine the statistically significant variations in performance throughout the LOFF sector. However, the lack of data reduction software for EDARC recordings did not permit this analysis to be carried out during data collection. Data were collected at much closer spacing than the anticipated requirement in order to compensate for this problem.

The simulation test configuration is shown in figure 3. A Flite-Trak 600 processor was used to simulate the LOFF input data stream. This is a commercially available unit designed to accept and process LOFF messages which has been specially modified to generate LOFF messages. The Flite-Trak 600 also has the capability to record input data on magnetic disk. The unit is manufactured by Offshore Navigation, Inc. (ONI). In addition, a dynamic simulator designed for in-house use by ONI was also leased for the simulation tests. This unit has the capability to generate up to 30 simultaneous LOFF messages at an update interval of 15 seconds, and move targets at user selected rates, headings, and altitudes.

The Flite-Trak 600 was used to generate a grid of 50 targets spaced at a regular interval. A group of 50 messages corresponding to these targets was repeated every 15 seconds. This allowed repetitive inputs for use in examining the conversion accuracy of EDARC without dynamic tracker effects, and to verify that the Infotec converter maintained a deterministic output. This configuration was used primarily to determine EDARC grid spacing in system coordinates for a particular lat/long spacing of inputs.

Infotec conversion accuracy data were collected throughout the LOFF sector, extending from 26° to 29° north latitude and from 90° to 96° west longitude. EDARC data were collected throughout a part of the sector extending from 27°30' to 29° in latitude and 90° to 96° in longitude. Site adaptation of the entire LOFF sector had not yet been accomplished at the time of simulation testing, precluding the collection of data throughout the sector. However, because EDARC is a certified system which has already undergone its own testing, it was determined that the amount of data collected was sufficient for purposes of the LOFF tests.

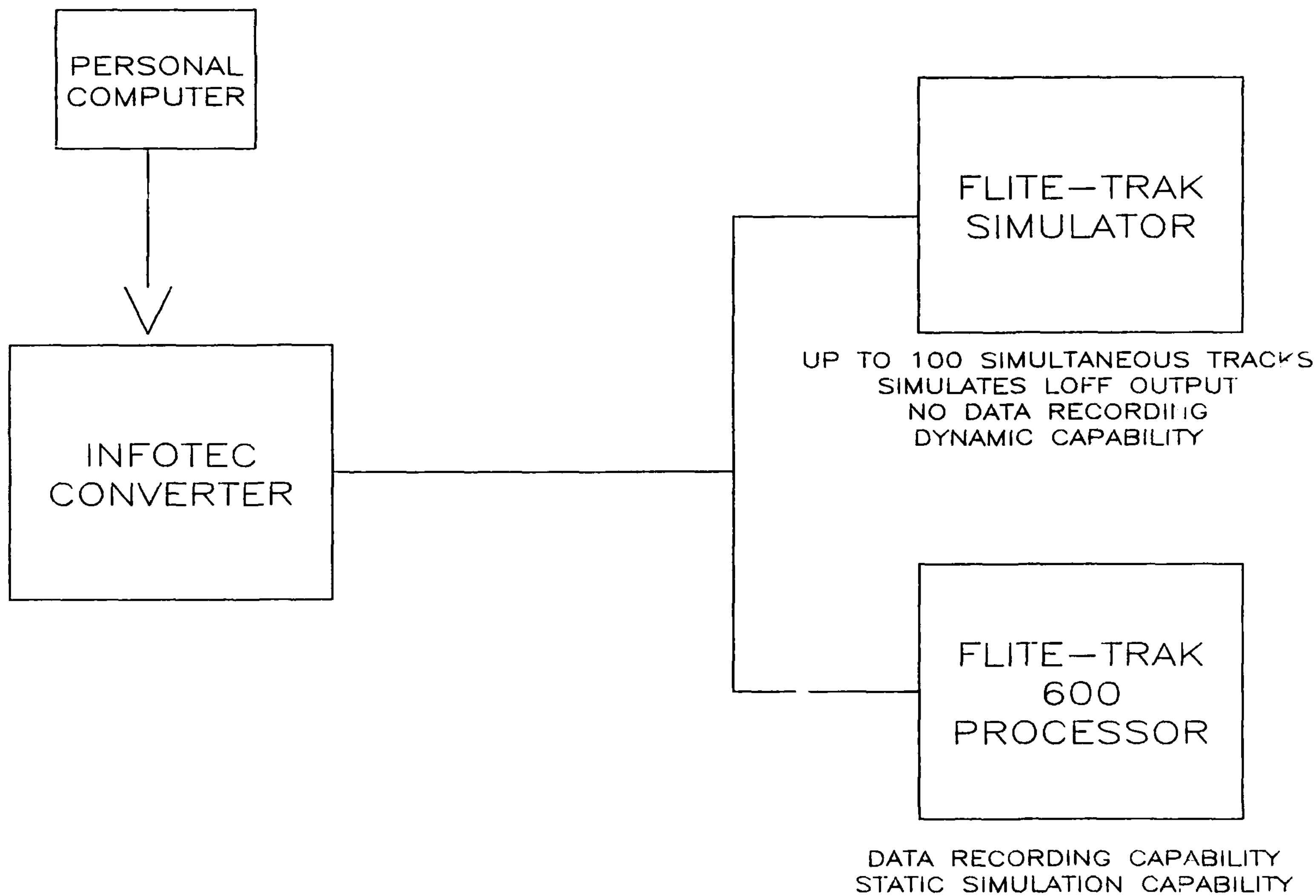

FIGURE 3. TEST CONFIGURATION FOR SIMULATION

FLIGHT TEST.

Flight tests were conducted over the Gulf of Mexico using a Convair 580 aircraft equipped with several navigational receivers, a LOFF interface, and data collection equipment. The aircraft was flown in the area approved for LOFF operations in a normal LOFF operational environment. The flight test routes are shown in figures 4 through 9.

The flight pattern selected to determine VHF data link coverage was to fly from one of the LOFF receiver sites directly to another. The procedure was simply to mark the points at which data were received at the ARTCC, based upon a controller's observation of the target on his Plan View Display (PVD). Flights were conducted at several altitudes to determine coverage at each. Because VHF radio is a line-of-site system, the available range depends primarily on altitude rather than signal output power, especially at the lower altitudes used in the offshore environment. Each VHF facility was overflown at each altitude in order to determine its performance. Flight profiles were constructed in a manner which covered the entire sector and also verified omnidirectional coverage of each facility. Orbits around stations were flown as required.

Several flights were conducted in areas of LOFF and radar coverage overlap. Probes were flown to radar sites at Alexandria and New Orleans, Louisiana, to determine whether their coverage extended into the LOFF sector. No significant overlap (greater than 2 miles) was detected. Where overlaps did exist partial orbits and radial routes were flown from each of the radar transmitters to determine relative performance between LOFF and radar.

A single high altitude probe was flown at flight level 200 to determine high altitude coverage of the system. The route selected was directly south of the QHI site. This is a route which would be used by internationally arriving flights which are currently handled manually due to the lack of radar coverage in the area.

Loran accuracy data were collected during the entire flight test. Loran accuracy was measured using the highly accurate Global Positioning System (GPS) as a position reference. Data were collected once per second from both types of Loran receivers, and at a nominal 1.2 second rate for GPS. Comparison of Loran to GPS provides an accuracy measure on the order of 30 meters in the horizontal plane.

DATA REDUCTION AND ANALYSIS

Data reduction was performed on a VAX 11/750 computer. All recorded data were transferred to the VAX, including tape recordings generated by EDARC and the airborne data collection equipment. Data processing is described below.

INFOTEC CONVERTER ACCURACY.

The Infotec converter has the capability to record a log data message which contains all the input and output information used in the conversion process. The input LOFF message is recorded, along with the results of the conversion in range and azimuth, and time of message input and message output. The log files

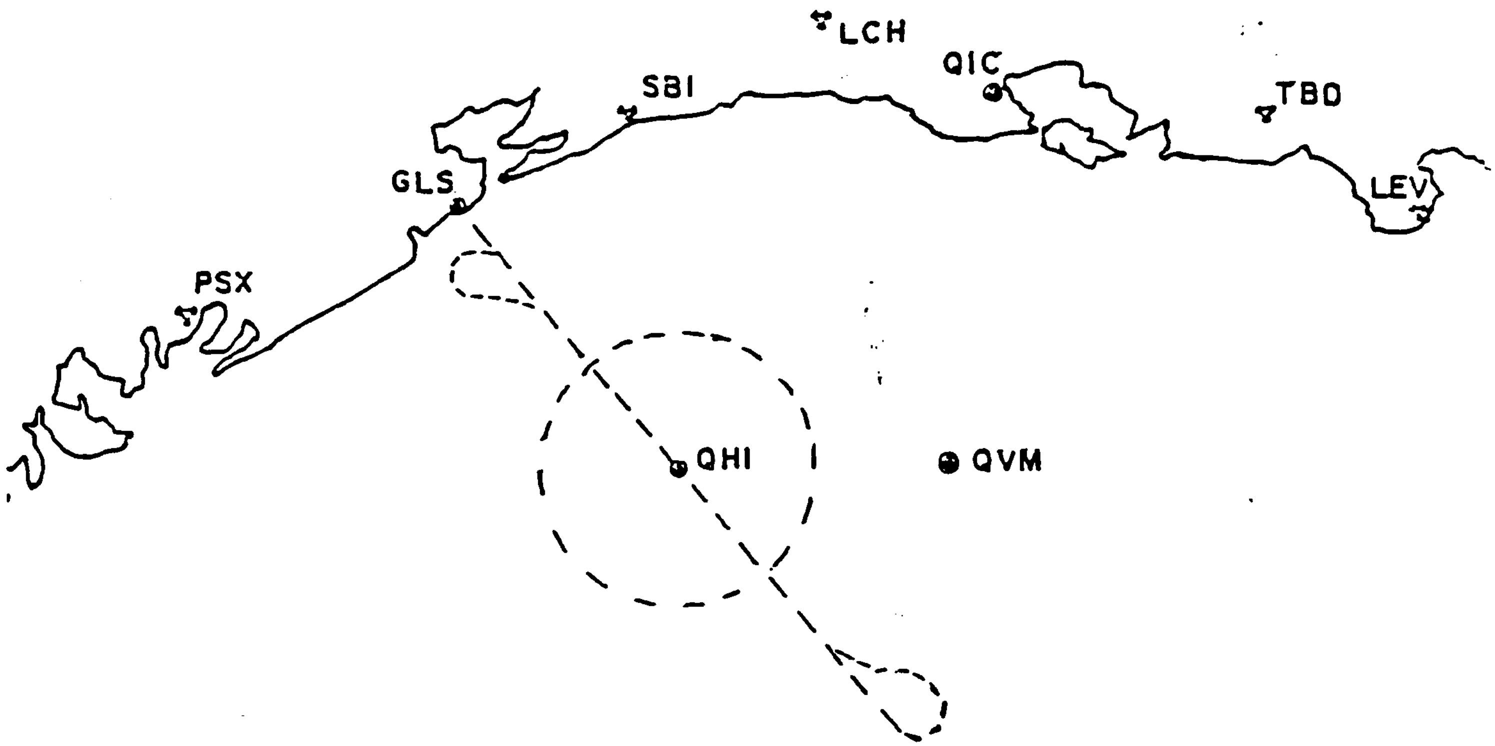

FIGURE 4. FLIGHT TEST ROUTE - QHI ORBIT AND VHF COVERAGE

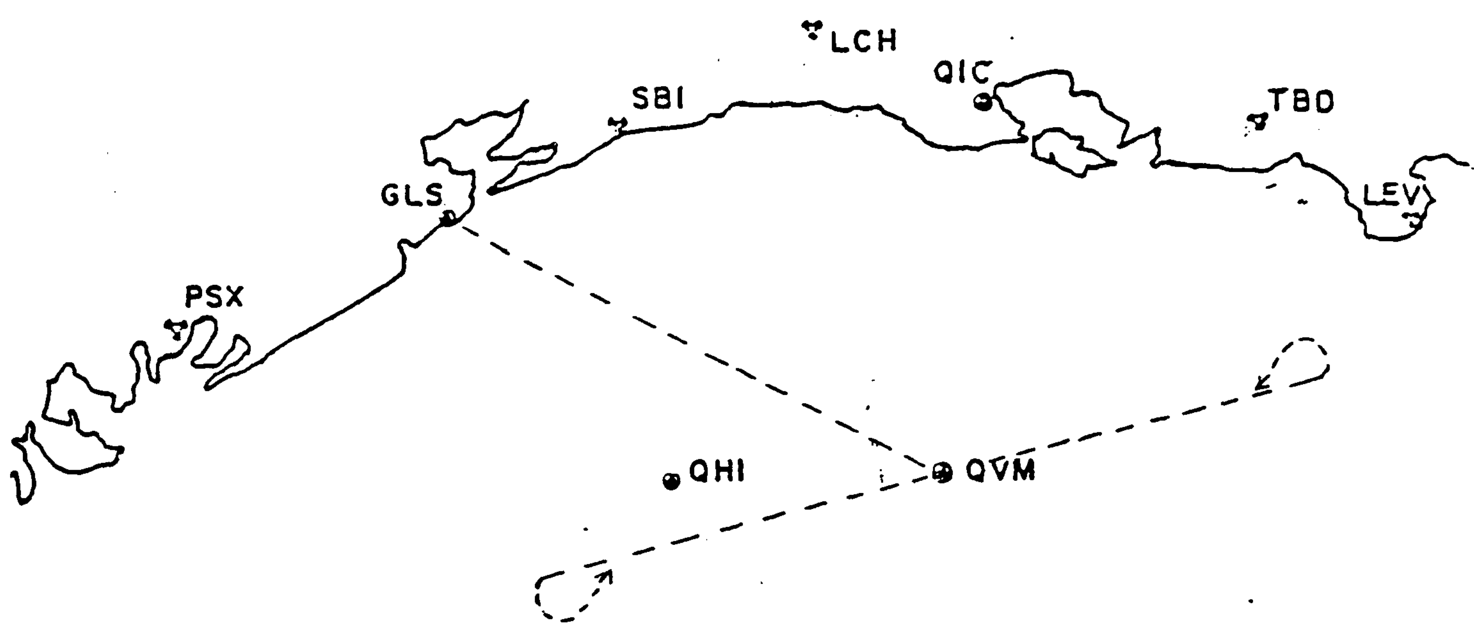

FIGURE 5. FLIGHT TEST ROUTE - QVM VHF COVERAGE

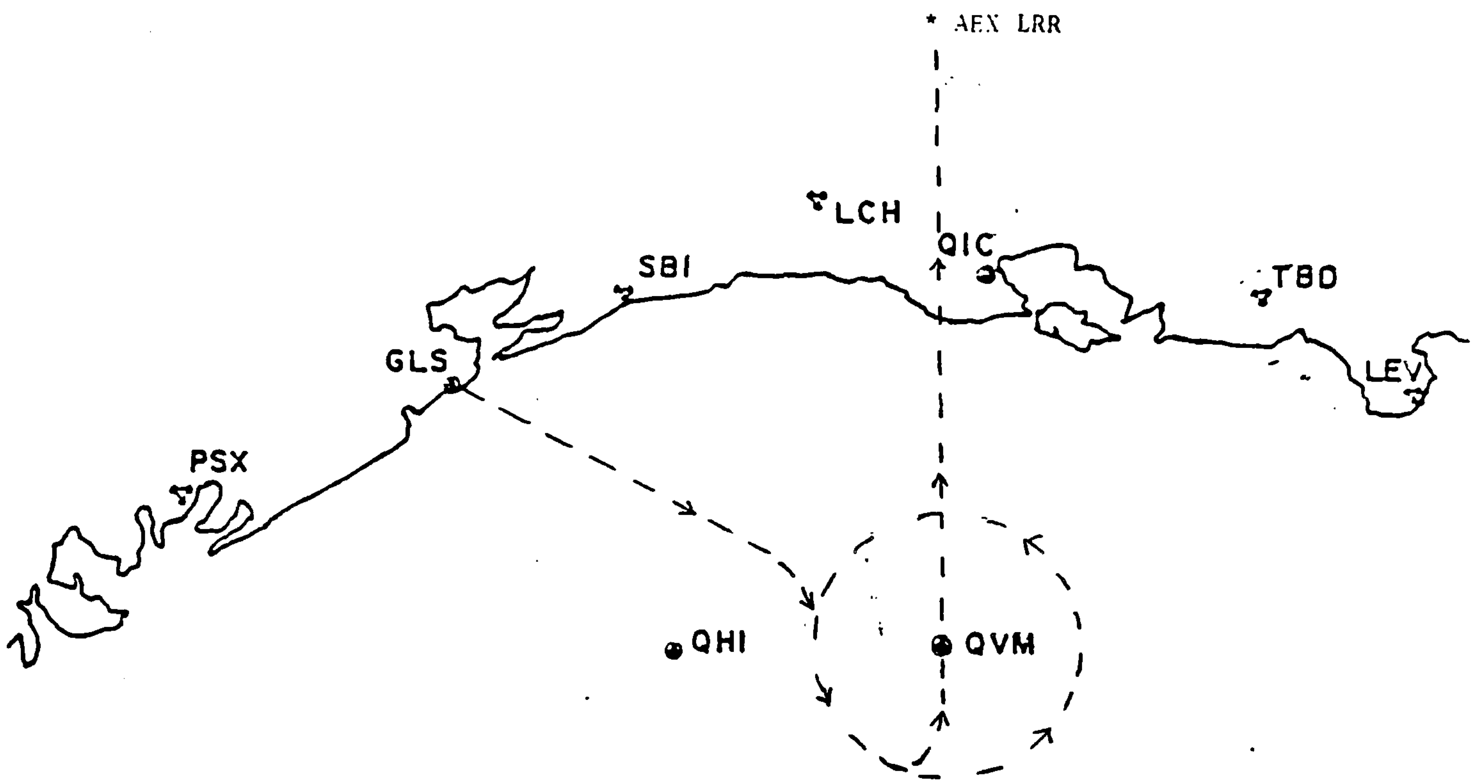

FIGURE 6. FLIGHT TEST ROUTE - QVM ORBIT AND AEX OVERLAP PROBE

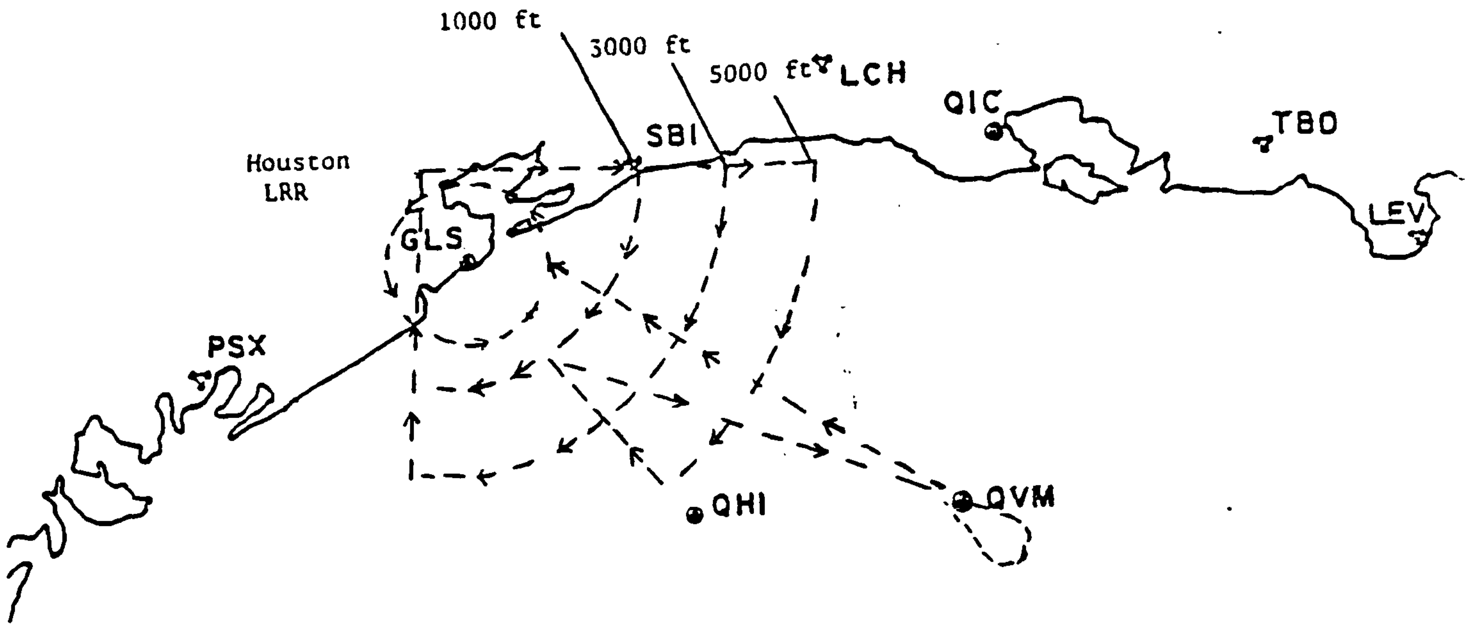

FIGURE 7. FLIGHT TEST ROUTE - GLS ORBIT AND RADAR OVERLAP AREA

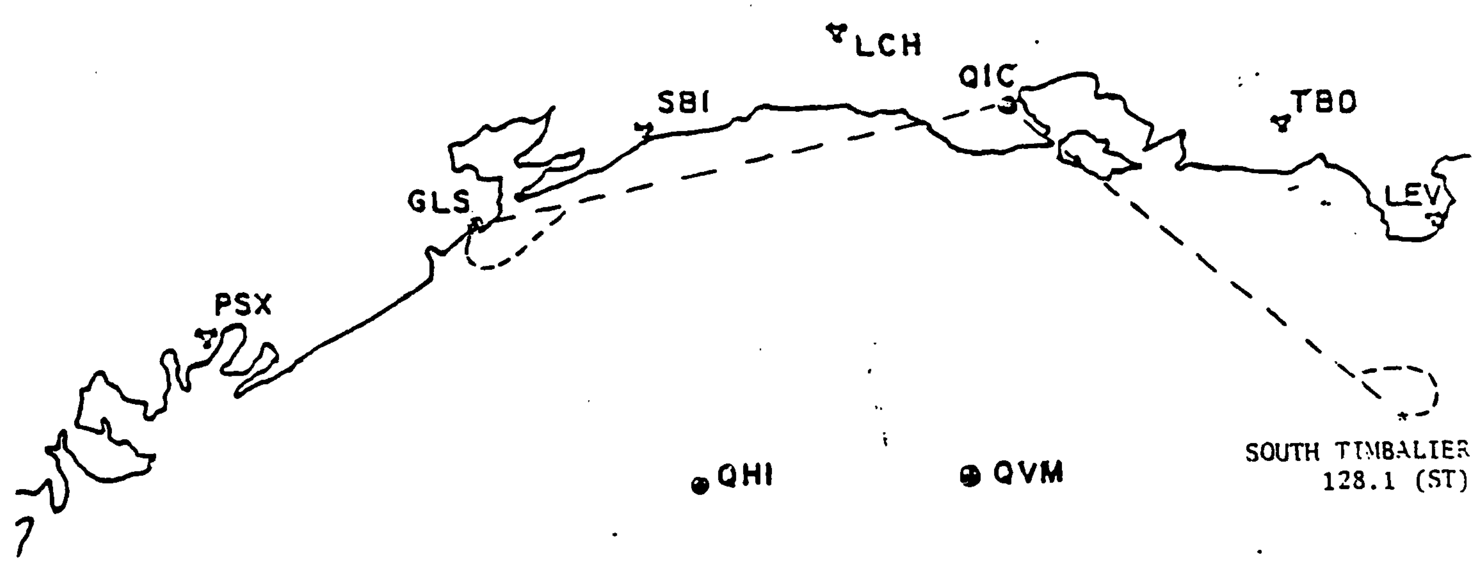

FIGURE 8. FLIGHT TEST ROUTE - QIC VHF COVERAGE

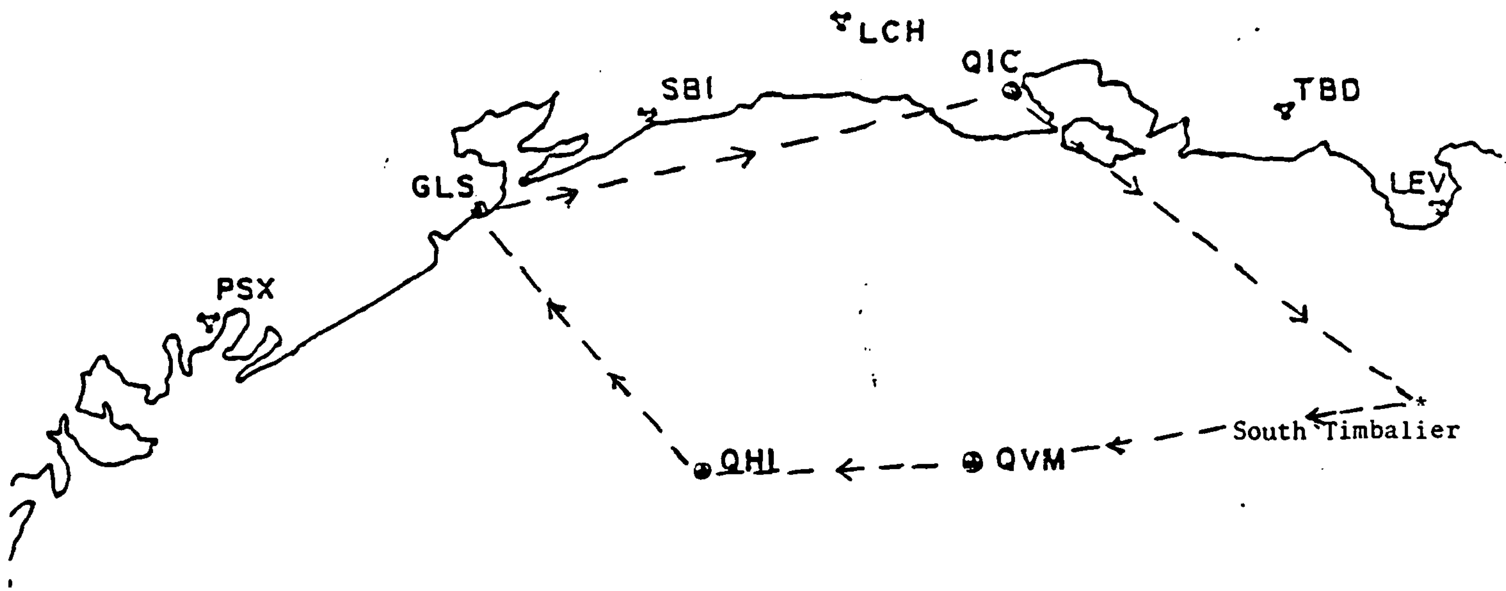

FIGURE 9. FLIGHT TEST ROUTE - ENTIRE LOFF SECTOR

were used to determine accuracy of the algorithm implementation. No attempt was made to verify the algorithm itself as this had been accomplished previously.

The conversion algorithm as described in the Converter Unit Technical Description was implemented on the VAX, and LOFF messages from the log files were processed through it. These results were compared to the actual output message as recorded in the log file. A mean and standard deviation were computed for comparison to the radar accuracy standard of 1/8 nmi in range and 2 azimuth change pulses (ACP's). An ACP is equal to 0.088°.

EDARC CONVERSION ACCURACY.

EDARC records data as they are posted to the controller's display. The data fields of interest are time, beacon code, and system x-y coordinates of the tracked target. Static targets were used to eliminate the effects of the tracking function. Samples were placed in bins according to beacon codes which correspond to particular lat/long positions. These bins were used to determine the mean and standard deviations of system x-y outputs for given lat/long inputs. Analysis of the data, however, showed that they were highly repeatable, indicating that the mean plus standard deviation analysis did not provide a clear indication of system performance.

The method employed to identify the system coordinates corresponding to input lat long was to determine the system output which occurred with most frequency for a given input. Statistically, this is known as the mode of a variable. It has more meaning, in this case, than the statistically expected value (mean) because of the discrete nature of the conversion output. System coordinates are not continuous but have discrete values at 1/16 nmi resolution. The statistical mode of the output was determined for each lat/long input.

It should be pointed out that the accuracy of a given coordinate conversion can only be determined with respect to a given transformation. That is, the conversion process maps points from one coordinate system into corresponding points in another system. Since system x-y coordinates have no physical basis, it is difficult to place an accuracy figure on the conversion process. What has been done here is to show the relationship between the coordinate systems (lat/long and system x-y), and to show how a given distance in one system is transformed into a distance in the other.

EDARC DYNAMIC ACCURACY.

EDARC dynamic accuracy was measured by comparing results from static simulation to results from the flight test. The array of system x-y coordinates corresponding to lat/long inputs were used to estimate static conversion coordinates for each reported aircraft position.

The first step was to merge airborne data and EDARC data together. This was done by matching the time of each EDARC record to the closest airborne time, which was within 1 second. The Loran position, as recorded in the airplane, was used as an index to the tables of static simulation data described above. This provides a measure of the actual aircraft position compared to the position displayed to the controller. It is a true end-to-end check of system performance.

The coordinates were estimated by interpolating between the four closest points in both x and y. For each coordinate the actual values were estimated independently. To estimate the system y coordinate, for example, the two columns were interpolated over y (which corresponds to lat) to produce an intermediate value for each. These values were then interpolated over x to produce the final value. The final interpolated position was compared to the position of the aircraft as determined by the EDARC tracker. The results indicate the influence of aircraft dynamics, primarily as a result of tracker effects.

COMPARATIVE PERFORMANCE IN OVERLAP AREAS.

Comparison of radar and LOFF targets was accomplished in the areas of common coverage of the two. Tracked position, as determined by EDARC, of both types of targets were compared on a point-by-point basis for all available data points. Results were expressed as a mean and standard deviation.

The results of this analysis contain some effects of the tracker function, and represent the actual differences in performance of the two systems as displayed to the controller.

LORAN ACCURACY.

Loran accuracies were determined with respect to a GPS position reference. For each point, the error term is the difference between Loran and GPS reported position. A position solution was obtained at 1-second rates from both Loran and GPS. For GPS, this required interpolation over the 1.2 second GPS update interval to estimate GPS position at the time of each Loran sample. Differences were summed for each flight to allow a mean and standard deviation to be computed.

VHF DATA LINK COVERAGE.

Coverage of the data link was determined by observing the loss or start of message reception as the aircraft flew into and out of coverage. The point at which this occurred was determined by controller observation of the point at which the first missed transmission occurred on an outbound leg, or the point at which the controller would determine radar contact (in a radar environment) on an inbound leg. This is a subjective measure but is estimated to be within 1 mile of the actual coverage due to the fact that the controller was handling a single aircraft and could provide special handling, particularly with respect to determination of the limits of LOFF coverage. During flight testing a failure of the EDARC data recording system occurred. The failure could not be recovered during the flight test but did not affect EDARC conversion, tracking, or display processes. Because of this failure, only the subjective appraisal by the controller was available to determine data link coverage.

TIME DELAYS.

Delays in the converter were determined from the log files. The converter time stamps input data and output data, posting both times to the log file. The differences were computed for each sample and reduced to a mean and standard deviation for all samples.

RESULTS

INFOTEC CONVERTER ACCURACY.

Results of the analysis of the Infotec converter performance during simulation, as compared to the specified algorithms, are presented in table 2. The sector was divided into smaller areas for testing purposes. The mean and standard deviation are presented for these various areas throughout the LOFF sector (and for the entire sector) at three altitudes.

Overall accuracy of the conversion as compared to the algorithm varies with altitude. At 1000 feet, where most of the data were collected, the accuracy is 0.29 nmi in range and 0.46 ACP's in azimuth throughout the entire sector. This does not meet the radar accuracy specification of 1/8 (0.125) nmi in range, but does meet the requirement of 2 ACP's (0.176°) in azimuth.

Differences between ranges and azimuths as computed by the VAX and the Infotec converter show a spatial variation as observed in the table. It can be seen that data computed for points further from the pseudo radar site tend to agree less than those closer to the site, with the exception of points within 30 miles of the site. The result is that conversion accuracy has the unintended characteristic of being dependent upon range from the site, just as an actual radar does.

The reason for the discrepancy has not yet been determined. As mentioned previously, every attempt was made in processing the data to adhere to the algorithm as published in the converter specification. Double precision arithmetic was used initially, but after the discrepancies were noticed the algorithm was recoded using single precision arithmetic with no difference in results.

EDARC CONVERSION ACCURACY.

The areas covered by simulated test points are shown for three altitudes in figures 10 through 12. The plots show the data points as recorded by the EDARC system when simulated targets were input at regular 6-minute spacings. Results showing the correspondence of lat/long inputs to EDARC-determined system x-y are presented in tables 3 through 5. Each table shows the system x-y outputs for a grid of lat/long, spaced at a 6-minute interval, for an area of the LOFF sector at a particular altitude. System x-y coordinates correspond to nautical miles in the table. The actual distance on the surface of the Earth for a 6-minute increment in lat is 6 nmi. For long, the actual distance follows the relation:

$$\text{Distance (nmi)} = \text{Distance (degrees)} \times \text{cosine (lat)} \times 60.$$

For a 6-minute increment in long in this area the actual distance is approximately 5.3 nmi.

Data were placed into groups, called data bins, at three altitudes: 100, 1000, and 4900 feet. Aggregate results are shown in table 6. The mean values represent the spacing in system coordinates for a 6-minute spacing each in lat and long. The first two columns show variation in system x and y with lat held constant. These numbers reflect changes in x and y moving horizontally through the data of tables 3 through 5. In a similar manner the last two columns (constant long) reflect changes moving vertically through the tables.

TABLE 2. INFOTEC CONVERTER ACCURACY

Area	Range (nmi)		Azimuth (ACP's)		
Longitude Deg Min - Deg Min	Mean	Std Dev	Mean	Std Dev	Samples
Altitude = 100 feet, 2 minute spacing					
96° 0' - 95° 0'	0.35	0.09	0.80	0.61	2670
95° 0' - 94° 0'	0.37	0.09	0.97	0.90	2701
94° 0' - 93° 0'	0.36	0.11	1.28	2.08	2670
93° 0' - 92° 0'	0.20	0.26	-0.82	15.01	2671
92° 0' - 91° 0'	-0.06	0.23	-3.21	1.98	2670
91° 0' - 90° 0'	-0.16	0.16	-2.04	0.62	2670
Entire Sector	0.18	0.27	-0.50	6.47	16052
Altitude = 1000 feet, 0.5 minute spacing					
95°30' - 95°15'	0.35	0.11	0.68	0.77	11947
95°15' - 95° 0'	0.37	0.19	0.87	1.07	10742
95° 0' - 94°45'	0.37	0.09	0.92	0.76	10741
94°45' - 94°30'	0.37	0.09	0.97	0.83	10719
94°30' - 94°15'	0.37	0.10	0.99	0.99	10893
94°15' - 94° 0'	0.37	0.14	1.07	1.18	10740
94° 0' - 93°45'	0.39	0.16	0.92	1.35	9554
93°45' - 93°30'	0.36	0.17	1.19	1.99	10723
93°30' - 93°15'	0.35	0.12	1.71	2.14	8970
93°15' - 93° 0'	0.33	0.14	1.93	2.89	8977
93° 0' - 92°45'	0.31	0.17	2.17	4.20	9045
92°45' - 92°30'	0.26	0.22	2.55	7.24	8970
92°30' - 92°15'	0.13	0.28	-0.87	25.48	8932
92°15' - 92° 0'	0.00	0.29	-4.85	6.31	8970
92° 0' - 91°45'	-0.06	0.26	-4.19	3.01	8970
91°45' - 91°30'	-0.04	0.19	-2.97	2.13	8970
91°30 - 91°15'	-0.13	0.20	-3.17	1.22	8970
91°15 - 91° 0'	-0.16	0.18	-2.76	0.90	8973
Entire Sector	0.29	0.22	0.46	7.18	148896
Altitude = 4900 feet, 2 minute spacing					
96° 0' - 95° 0'	0.35	0.10	0.79	0.61	2680
95° 0' - 94° 0'	0.37	0.08	0.99	0.91	2670
94° 0' - 93° 0'	0.36	0.11	1.26	2.06	2670
93° 0' - 92° 0'	0.20	0.25	-0.61	14.74	2670
92° 0' - 91° 0'	-0.06	0.23	-3.23	1.98	2670
91° 0' - 90° 0'	-0.16	0.16	-2.03	0.62	2670
Entire Sector	0.18	0.27	-0.47	6.37	16030

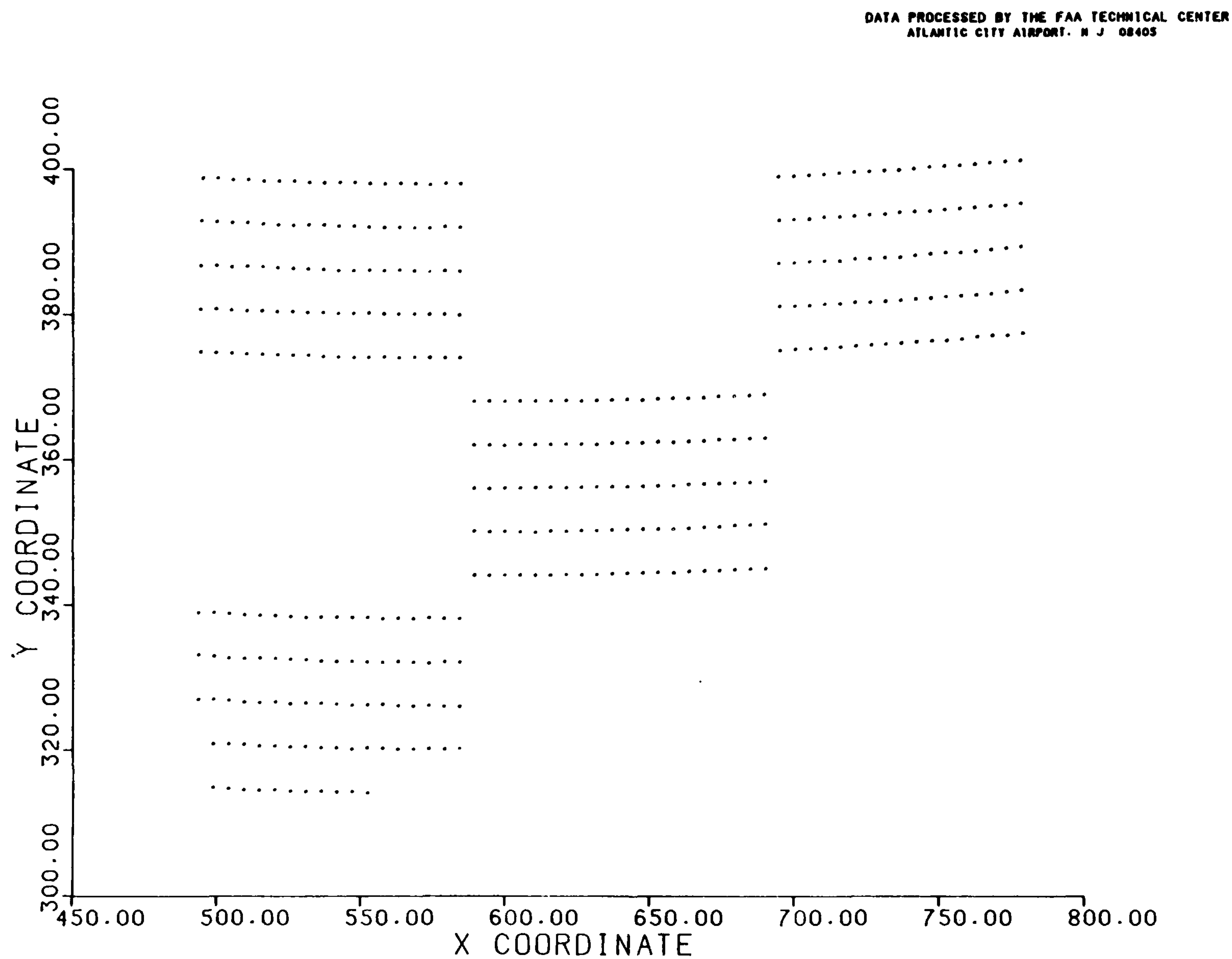

FIGURE 10. EDARC SIMULATION AREA - 100 FEET ALTITUDE

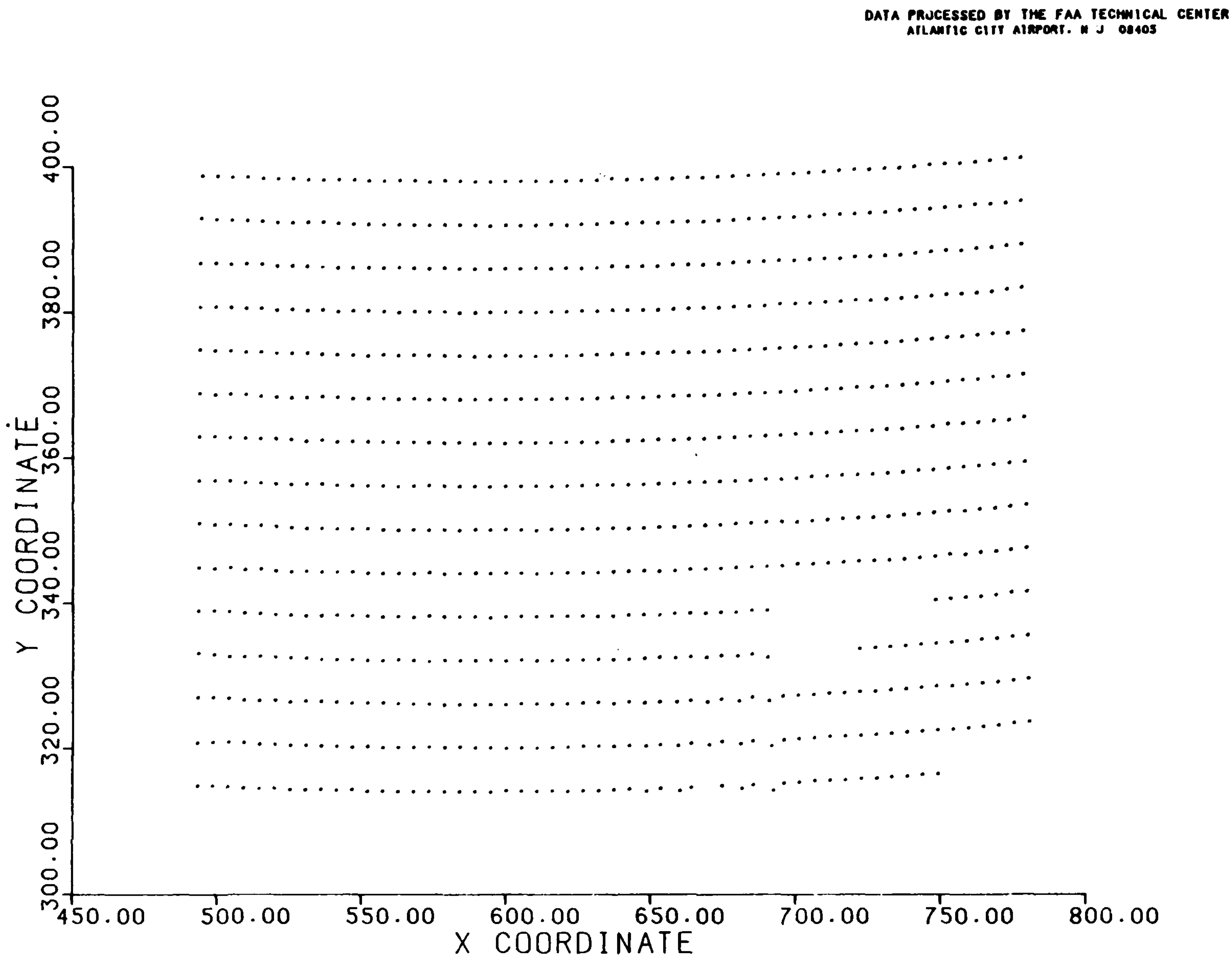

FIGURE 11. EDARC SIMULATION AREA - 1000 FEET ALTITUDE

DATA PROCESSED BY THE FAA TECHNICAL CENTER
ATLANTIC CITY AIRPORT, N J 08405

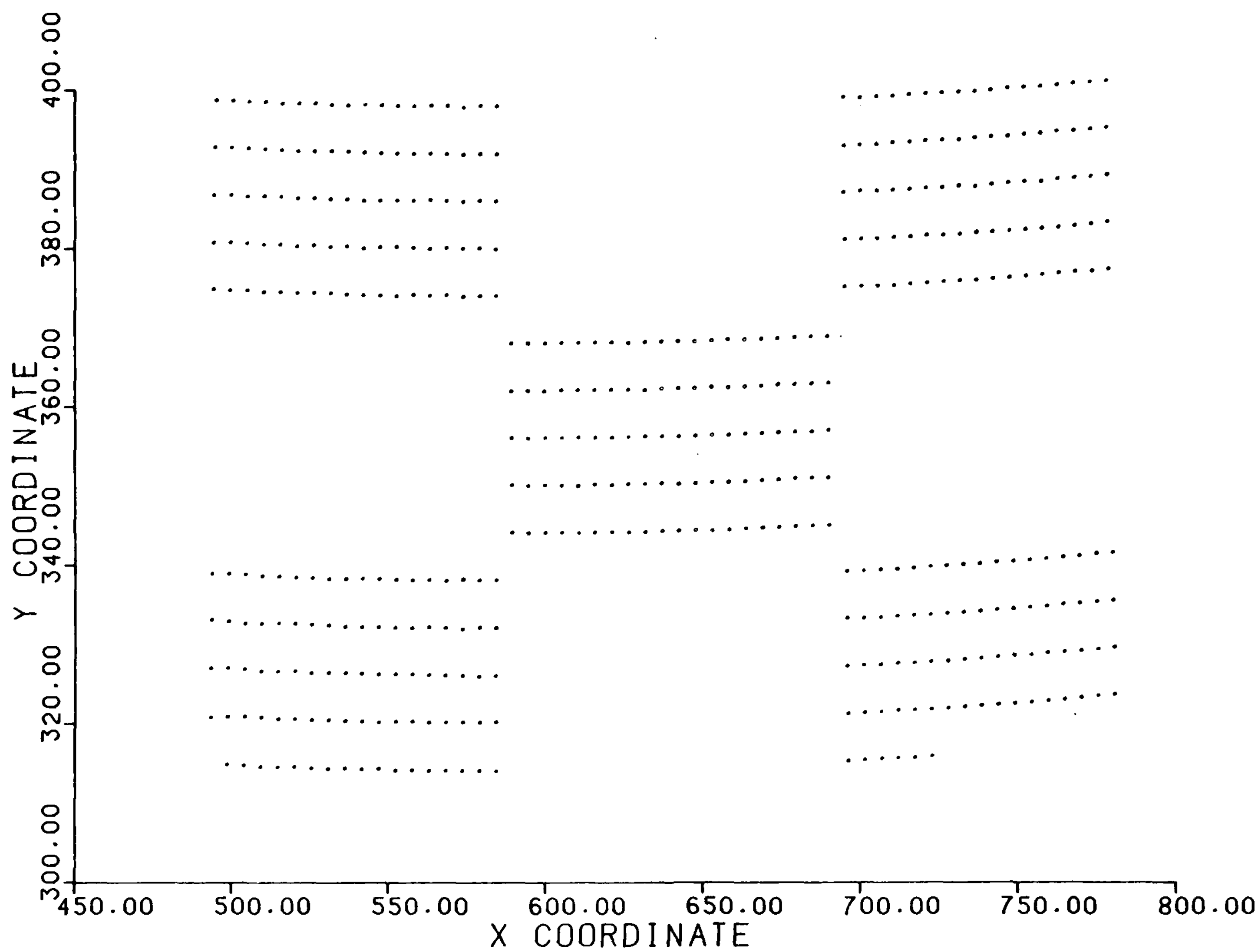

FIGURE 12. EDARC SIMULATION AREA - 4900 FEET ALTITUDE

TABLE 3. EDARC X-Y POSITION IN MILES
AT 100 FEET ALTITUDE

Lat \ Long —> Deg Min	Deg Min 96 00'	95 54'	95 48'	95 42'	95 36'	95 30'	95 24'	95 18'	95 12'	95 6'
29 0'	0.000 0.000	0.000 0.000	398.375 493.563	398.313 498.813	398.125 503.938	398.125 509.188	397.938 514.563	397.938 519.813	397.938 525.063	397.750 530.250
28 54'	0.000 0.000	0.000 0.000	392.438 493.563	392.375 498.688	392.250 503.938	392.188 509.313	392.063 514.500	391.938 519.750	391.875 524.938	391.938 530.313
28 48'	0.000 0.000	0.000 0.000	386.375 493.188	386.375 498.563	386.188 503.813	386.250 509.125	386.188 514.438	385.938 519.688	385.938 524.938	385.875 530.063
28 42'	0.000 0.000	0.000 0.000	380.375 493.125	380.375 498.438	380.250 503.688	380.125 508.938	380.125 514.188	379.875 519.500	380.000 524.813	379.813 530.063
28 36'	0.000 0.000	0.000 0.000	374.500 493.063	374.375 498.250	374.313 503.625	374.125 508.875	374.125 514.188	374.000 519.500	374.000 524.813	374.000 530.125
28 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 0'	0.000 0.000	0.000 0.000	338.563 492.375	338.563 497.688	338.438 502.938	338.250 508.250	338.188 513.625	338.063 519.000	338.000 524.250	337.875 529.563
27 54'	0.000 0.000	0.000 0.000	332.750 492.313	332.563 497.625	332.250 502.938	332.250 508.188	332.313 513.563	332.250 518.875	332.125 524.188	332.063 529.563
27 48'	0.000 0.000	0.000 0.000	326.625 492.188	326.625 497.500	326.500 502.813	326.250 508.063	326.188 513.438	326.250 518.875	326.000 524.063	326.063 529.563
27 42'	0.000 0.000	0.000 0.000	320.438 492.063	320.500 497.375	320.500 502.750	320.438 508.063	320.188 513.438	320.188 518.750	320.063 524.063	320.063 529.438
27 36'	0.000 0.000	0.000 0.000	0.000 0.000	314.500 497.313	314.375 502.625	314.188 507.938	314.125 513.313	314.188 518.625	314.000 524.000	313.938 529.313
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

Entry Format: x.xxx - system y coordinate
x.xxx - system x coordinate

TABLE 3. EDARC X-Y POSITION IN MILES AT 100 FEET ALTITUDE (CONTINUED)

	95 0'	94 54'	94 48'	94 42'	94 36'	94 30'	94 24'	94 18'	94 12'	94 6'
29 00'	397.688 535.500	397.750 540.875	397.688 546.188	397.625 551.313	397.563 556.563	397.625 561.938	397.563 567.188	397.375 572.250	397.563 577.625	397.500 582.813
28 54'	391.875 535.688	391.750 540.750	391.625 546.063	391.625 551.188	391.563 556.500	391.563 561.750	391.500 567.000	391.438 572.250	391.500 577.625	391.438 582.875
28 48'	385.813 535.375	385.625 540.625	385.625 545.875	385.688 551.313	385.625 556.500	385.688 561.875	385.563 567.000	385.500 572.313	385.563 577.563	385.500 582.750
28 42'	379.875 535.313	379.625 540.625	379.750 545.875	379.813 551.188	379.688 556.563	379.500 561.688	379.625 567.063	379.563 572.250	379.563 577.500	379.438 582.688
28 36'	373.813 535.188	373.750 540.438	373.688 545.875	373.625 551.063	373.750 556.438	373.625 561.625	373.688 566.938	373.500 572.313	373.563 577.563	373.563 582.750
28 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 0'	337.875 534.938	337.938 540.250	337.875 545.563	337.813 550.938	337.688 556.125	337.750 561.438	337.625 566.813	337.813 572.125	337.688 577.313	337.688 582.688
27 54'	331.875 534.813	331.813 540.125	331.813 545.438	331.750 550.688	331.688 556.000	331.813 561.438	331.688 566.688	331.563 572.063	331.750 577.500	331.688 582.750
27 48'	326.000 534.875	325.938 540.063	325.813 545.438	325.875 550.813	325.875 556.188	325.750 561.438	325.688 566.625	325.688 572.125	325.563 577.375	325.625 582.688
27 42'	319.938 534.688	319.875 540.063	319.750 545.375	319.875 550.750	319.875 556.063	319.750 561.313	319.750 566.688	319.813 572.063	319.750 577.438	319.813 582.688
27 36'	314.000 534.625	313.875 540.000	313.938 545.375	313.750 550.688	313.750 556.000	313.688 561.313	313.688 566.688	313.688 571.938	313.688 577.375	313.625 582.750
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.0C0	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

TABLE 3. EDARC X-Y POSITION IN MILES
AT 100 FEET ALTITUDE (CONTINUED)

	94 0'	93 54'	93 48'	93 42'	93 36'	93 30'	93 24'	93 18'	93 12'	93 6'
29 0'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 54'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 48'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 42'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 36'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 30'	367.563 588.000	367.563 593.375	367.563 598.625	367.625 603.875	367.625 609.188	367.625 614.500	367.688 619.750	367.625 625.000	367.688 630.250	367.750 635.500
28 24'	361.500 588.063	361.563 593.250	361.500 598.438	361.625 603.875	361.625 609.063	361.625 614.375	361.688 619.688	361.688 625.000	361.625 630.250	361.813 635.625
28 18'	355.625 588.000	355.563 593.188	355.625 598.625	355.625 603.938	355.688 609.188	355.625 614.500	355.688 619.813	355.750 625.063	355.813 630.250	355.813 635.625
28 12'	349.688 588.125	349.625 593.313	349.688 598.563	349.625 603.938	349.563 609.188	349.750 614.438	349.688 619.813	349.813 625.063	349.813 630.313	349.875 635.625
28 6'	343.688 588.125	343.625 593.250	343.688 598.625	343.688 603.875	343.625 609.250	343.688 614.375	343.750 619.813	343.750 625.188	343.750 630.375	343.875 635.750
28 0'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 54'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 48'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 42'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 36'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

TABLE 3. EDARC X-Y POSITION IN MILES
AT 100 FEET ALTITUDE (CONTINUED)

	93 0'	92 54'	92 48'	92 42'	92 36'	92 30'	92 24'	92 18'	92 12'	92 6'
29 0'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 54'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 48'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 42'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 36'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 30'	367.813 640.750	367.750 646.063	367.875 651.438	368.000 656.563	368.000 661.875	368.063 667.188	368.125 672.313	368.250 677.688	368.375 682.938	368.375 688.125
28 24'	361.875 640.875	361.875 646.063	362.000 651.438	361.938 656.750	362.063 662.000	362.125 667.250	362.313 672.500	362.313 677.688	362.438 683.063	362.500 688.375
28 18'	355.813 640.938	355.875 646.250	355.938 651.500	355.938 656.813	356.125 662.063	356.188 667.313	356.250 672.563	356.313 677.875	356.375 683.188	356.563 688.500
28 12'	349.813 641.000	349.875 646.313	350.000 651.563	350.000 656.813	350.125 662.125	350.250 667.438	350.313 672.688	350.500 677.938	350.563 683.250	350.563 688.500
28 6'	343.938 640.938	344.000 646.313	343.938 651.563	344.000 656.938	344.188 662.250	344.250 667.500	344.313 672.750	344.438 678.000	344.500 683.375	344.563 688.625
28 0'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 54'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 48'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 42'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 36'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

TABLE 3. EDARC X-Y POSITION IN MILES
AT 100 FEET ALTITUDE (CONTINUED)

	92 0'	91 54'	91 48'	91 42'	91 36'	91 30'	91 24'	91 18'	91 12'	91 6'
29 0'	398.500 692.813	398.438 698.125	398.563 703.375	398.688 708.625	398.875 713.875	399.000 719.125	399.063 724.313	399.188 729.563	399.250 734.750	399.438 739.875
28 54'	392.375 693.063	392.500 698.188	392.563 703.563	392.813 708.688	392.875 714.125	393.063 719.188	393.125 724.438	393.188 729.813	393.438 734.938	393.563 740.125
28 48'	386.500 693.000	386.688 698.375	386.688 703.688	386.813 708.813	386.938 714.188	387.063 719.375	387.125 724.625	387.375 729.875	387.313 735.125	387.563 740.313
28 42'	380.563 693.313	380.625 698.563	380.688 703.688	380.875 709.000	380.938 714.313	381.125 719.500	381.125 724.750	381.250 730.063	381.500 735.375	381.563 740.500
28 36'	374.625 693.313	374.688 698.688	374.750 703.875	374.813 709.125	375.000 714.313	375.125 719.688	375.250 725.000	375.438 730.125	375.500 735.375	375.688 740.688
28 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 0'	338.750 694.063	338.813 699.375	339.000 704.750	339.063 710.063	339.188 715.250	339.375 720.625	339.500 725.750	339.625 731.125	339.750 736.375	339.938 741.750
27 54'	332.875 694.188	332.875 699.438	333.000 704.875	333.125 710.125	333.250 715.438	333.313 720.688	333.500 726.063	333.625 731.250	333.750 736.625	333.938 741.938
27 48'	326.813 694.313	326.938 699.563	327.000 704.938	327.188 710.250	327.250 715.563	327.375 720.813	327.500 726.188	327.688 731.500	327.813 736.813	328.000 742.125
27 42'	320.813 694.500	320.938 699.750	321.063 705.000	321.250 710.438	321.313 715.688	321.375 721.000	321.563 726.313	321.688 731.625	321.875 737.000	322.000 742.313
27 36'	314.875 694.563	315.000 699.875	315.188 705.250	315.250 710.500	315.313 715.813	315.500 721.250	315.563 726.563	315.750 731.750	315.813 737.125	316.063 742.438
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

TABLE 3. EDARC X-Y POSITION IN MILES
AT 100 FEET ALTITUDE (CONTINUED)

	91 0'	90 54'	90 48'	90 42'	90 36'	90 30'	90 24'	90 18'	90 12'	90 6'
29 0'	399.688	399.813	399.875	400.063	400.250	400.438	400.563	0.000	0.000	0.000
	745.250	750.438	755.688	761.000	766.125	771.438	776.688	0.000	0.000	0.000
28 54'	393.625	393.875	394.000	394.250	394.313	394.500	394.688	0.000	0.000	0.000
	745.438	750.625	755.813	761.000	766.375	771.688	776.813	0.000	0.000	0.000
28 48'	387.750	387.938	387.938	388.250	388.375	388.563	388.750	0.000	0.000	0.000
	745.625	750.813	756.125	761.375	766.625	771.813	776.938	0.000	0.000	0.000
28 42'	381.688	381.875	382.000	382.125	382.313	382.563	382.813	0.000	0.000	0.000
	745.813	751.000	756.313	761.563	766.750	772.000	777.125	0.000	0.000	0.000
28 36'	375.813	376.000	376.188	376.375	376.563	376.625	376.875	0.000	0.000	0.000
	746.000	751.250	756.438	761.688	766.938	772.313	777.438	0.000	0.000	0.000
28 30'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28 24'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28 18'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28 12'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28 6'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28 0'	340.000	340.188	340.375	340.563	340.688	341.000	341.125	0.000	0.000	0.000
	747.063	752.313	757.563	762.938	768.125	773.500	778.750	0.000	0.000	0.000
27 54'	334.063	334.250	334.375	334.625	334.750	334.938	335.125	0.000	0.000	0.000
	747.188	752.500	757.813	763.063	768.375	773.750	779.000	0.000	0.000	0.000
27 48'	328.188	328.250	328.500	328.625	328.750	328.938	329.188	0.000	0.000	0.000
	747.375	752.750	758.000	763.313	768.688	774.000	779.250	0.000	0.000	0.000
27 42'	322.125	322.313	322.438	322.625	322.813	323.063	323.250	0.000	0.000	0.000
	747.625	752.938	758.313	763.500	768.813	774.125	779.375	0.000	0.000	0.000
27 36'	316.125	316.375	316.500	316.750	317.000	317.063	317.313	0.000	0.000	0.000
	747.813	753.125	758.438	763.688	769.063	774.313	779.563	0.000	0.000	0.000
27 30'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 24'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 18'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 12'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 6'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 4. EDARC X-Y POSITION IN MILES AT 1000 FEET ALTITUDE

Lat \ Deg	Min	Lon --> Deg Min 96 00'	95 54'	95 48'	95 42'	95 36'	95 30'	95 24'	95 18'	95 12'	95 6'
29	0'	0.000	0.000	398.375	398.313	398.125	398.125	397.938	397.938	397.938	397.750
		0.000	0.000	493.563	498.813	503.938	509.188	514.563	519.813	525.063	530.250
28	54'	0.000	0.000	392.563	392.375	392.250	392.188	392.063	391.938	391.875	391.938
		0.000	0.000	493.438	498.688	503.938	509.313	514.500	519.750	524.938	530.313
28	48'	0.000	0.000	386.375	386.375	386.188	386.250	386.188	385.938	385.938	385.875
		0.000	0.000	493.188	498.563	503.813	509.125	514.438	519.688	524.938	530.063
28	42'	0.000	0.000	380.375	380.375	380.250	380.125	380.125	379.875	380.000	379.813
		0.000	0.000	493.125	498.438	503.688	508.938	514.188	519.500	524.813	530.063
28	36'	0.000	0.000	374.500	374.375	374.313	374.125	374.125	374.000	374.000	374.000
		0.000	0.000	493.063	498.250	503.625	508.875	514.188	519.500	524.813	530.125
28	30'	0.000	0.000	368.500	368.313	368.375	368.313	368.063	368.000	367.875	367.875
		0.000	0.000	492.938	498.250	503.500	508.813	514.000	519.375	524.625	529.875
28	24'	0.000	0.000	362.563	362.563	362.375	362.313	362.250	362.250	362.125	361.875
		0.000	0.000	492.875	498.125	503.375	508.688	514.000	519.313	524.563	529.750
28	18'	0.000	0.000	356.500	356.500	356.438	356.188	356.125	356.063	355.938	356.000
		0.000	0.000	492.688	498.063	503.313	508.625	513.938	519.125	524.438	529.875
28	12'	0.000	0.000	350.625	350.438	350.438	350.250	350.313	350.188	350.000	349.875
		0.000	0.000	492.625	497.875	503.188	508.500	513.938	519.188	524.438	529.750
28	6'	0.000	0.000	344.500	344.375	344.500	344.188	344.313	344.063	343.938	344.000
		0.000	0.000	492.375	497.750	503.188	508.313	513.813	518.938	524.313	529.563
28	0'	0.000	0.000	338.563	338.563	338.438	338.250	338.188	338.063	338.000	337.875
		0.000	0.000	492.375	497.688	502.938	508.250	513.625	519.000	524.250	529.563
27	54'	0.000	0.000	332.750	332.563	332.250	332.250	332.313	332.250	332.125	332.063
		0.000	0.000	492.313	497.625	502.938	508.188	513.563	518.875	524.188	529.563
27	48'	0.000	0.000	326.625	326.625	326.500	326.250	326.188	326.250	326.000	326.125
		0.000	0.000	492.188	497.500	502.813	508.063	513.438	518.875	524.063	529.438
27	42'	0.000	0.000	320.438	320.500	320.500	320.438	320.188	320.188	320.063	320.063
		0.000	0.000	492.063	497.375	502.750	508.063	513.438	518.750	524.063	529.438
27	36'	0.000	0.000	314.500	314.500	314.375	314.188	314.125	314.188	314.000	313.938
		0.000	0.000	492.188	497.313	502.625	507.938	513.313	518.625	524.000	529.313
27	30'	0.000	0.000	0.000	308.375	308.375	308.313	308.188	308.188	308.125	307.938
		0.000	0.000	0.000	497.125	502.500	507.938	513.250	518.563	523.938	529.250
27	24'	0.000	0.000	0.000	302.563	302.438	302.250	302.313	302.250	302.063	302.125
		0.000	0.000	0.000	497.125	502.375	507.750	513.188	518.438	523.875	529.188
27	18'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	12'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	6'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Entry Format: x.xxx - system y coordinate
x.xxx - system x coordinate

TABLE 4. EDARC X-Y POSITION IN MILES AT 1000 FEET ALTITUDE (CONTINUED)

	95 0'	94 54'	94 48'	94 42'	94 36'	94 30'	94 24'	94 18'	94 12'	94 6'
29 0'	397.688 535.500	397.750 540.875	397.688 546.188	397.625 551.313	397.563 556.563	397.625 561.938	397.563 567.188	397.375 572.250	397.563 577.625	397.500 582.813
28 54'	391.938 535.563	391.750 540.750	391.625 546.063	391.625 551.188	391.563 556.500	391.563 561.750	391.500 567.000	391.438 572.250	391.500 577.625	391.500 582.813
28 48'	385.813 535.375	385.625 540.625	385.625 545.875	385.688 551.313	385.625 556.500	385.688 561.875	385.563 567.000	385.500 572.313	385.563 577.563	385.500 582.750
28 42'	379.875 535.313	379.625 540.625	379.750 545.875	379.813 551.188	379.688 556.563	379.500 561.688	379.625 567.063	379.563 572.250	379.563 577.500	379.438 582.688
28 36'	373.813 535.188	373.750 540.438	373.688 545.875	373.625 551.063	373.750 556.438	373.625 561.625	373.688 566.938	373.625 572.188	373.563 577.563	373.563 582.750
28 30'	368.000 535.250	367.875 540.500	367.688 545.750	367.750 551.125	367.750 556.438	367.625 561.563	367.688 567.000	367.563 572.188	367.625 577.438	367.563 582.813
28 24'	362.000 535.188	361.750 540.438	361.813 545.750	361.813 551.063	361.750 556.313	361.688 561.500	361.688 566.938	361.625 572.250	361.563 577.500	361.625 582.688
28 18'	356.000 535.125	355.813 540.313	355.750 545.625	355.750 550.938	355.750 556.313	355.625 561.500	355.688 566.938	355.750 572.188	355.688 577.438	355.625 582.750
28 12'	349.875 535.000	349.813 540.313	349.813 545.563	349.875 550.938	349.688 556.250	349.625 561.500	349.688 566.750	349.625 572.063	349.625 577.438	349.563 582.625
28 6'	343.875 534.875	343.875 540.250	343.875 545.563	343.750 550.875	343.688 556.063	343.688 561.500	343.625 566.813	343.750 572.125	343.563 577.313	343.625 582.625
28 0'	337.875 534.938	337.938 540.250	337.875 545.563	337.875 550.813	337.688 556.125	337.750 561.438	337.625 566.813	337.813 572.125	337.688 577.313	337.688 582.688
27 54'	331.875 534.813	331.813 540.125	331.813 545.438	331.750 550.688	331.688 556.000	331.813 561.438	331.688 566.688	331.563 572.063	331.750 577.500	331.688 582.750
27 48'	326.063 534.750	325.938 540.063	325.813 545.438	325.875 550.813	325.875 556.188	325.750 561.438	325.688 566.625	325.688 572.125	325.563 577.375	325.625 582.688
27 42'	319.938 534.688	319.875 540.063	319.750 545.375	319.875 550.750	319.750 556.000	319.750 561.313	319.750 566.688	319.813 572.063	319.750 577.438	319.813 582.688
27 36'	314.000 534.625	313.875 540.000	313.938 545.375	313.750 550.688	313.750 556.000	313.688 561.313	313.688 566.688	313.688 571.938	313.688 577.375	313.688 582.625
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

TABLE 4. EDARC X-Y POSITION IN MILES
AT 1000 FEET ALTITUDE (CONTINUED)

	94 0'	93 54'	93 48'	93 42'	93 36'	93 30'	93 24'	93 18'	93 12'	93 6'
29 0'	397.375	397.375	397.438	397.438	397.500	397.438	397.500	397.563	397.563	397.688
	588.063	593.250	598.438	603.813	609.063	614.375	619.500	624.750	630.125	635.313
28 54'	391.438	391.313	391.438	391.375	391.438	391.563	391.438	391.563	391.563	391.688
	588.125	593.250	598.688	603.688	609.000	614.375	619.688	624.750	630.125	635.375
28 48'	385.438	385.438	385.500	385.438	385.563	385.500	385.563	385.500	385.563	385.688
	588.000	593.313	598.500	603.750	609.125	614.375	619.500	624.875	630.125	635.375
28 42'	379.438	379.500	379.500	379.500	379.500	379.563	379.563	379.688	379.625	379.688
	588.063	593.250	598.500	603.750	609.063	614.375	619.563	625.000	630.188	635.500
28 36'	373.438	373.500	373.563	373.500	373.500	373.625	373.563	373.625	373.688	373.688
	587.938	593.188	598.625	603.813	609.063	614.375	619.625	624.875	630.125	635.438
28 30'	367.563	367.563	367.563	367.625	367.625	367.625	367.688	367.625	367.688	367.750
	588.000	593.375	598.625	603.875	609.188	614.500	619.750	625.000	630.250	635.500
28 24'	361.500	361.563	361.500	361.625	361.625	361.625	361.688	361.688	361.625	361.813
	588.063	593.250	598.438	603.875	609.063	614.375	619.688	625.000	630.250	635.625
28 18'	355.625	355.563	355.625	355.625	355.688	355.625	355.688	355.750	355.813	355.813
	588.000	593.188	598.625	603.938	609.188	614.500	619.813	625.063	630.250	635.625
28 12'	349.688	349.625	349.688	349.625	349.563	349.750	349.688	349.813	349.813	349.875
	588.125	593.313	598.563	603.938	609.188	614.438	619.813	625.063	630.313	635.625
28 6'	343.688	343.625	343.688	343.688	343.625	343.688	343.750	343.750	343.750	343.875
	588.125	593.250	598.625	603.875	609.250	614.375	619.813	625.188	630.375	635.750
28 0'	337.688	337.563	337.688	337.750	337.750	337.813	337.813	337.813	337.750	337.813
	588.000	593.313	598.625	603.938	609.250	614.500	619.875	625.125	630.375	635.688
27 54'	331.688	331.750	331.625	331.750	331.688	331.688	331.813	331.813	331.875	331.875
	588.125	593.375	598.563	603.938	609.250	614.500	619.813	625.188	630.500	635.750
27 48'	325.625	325.625	325.625	325.750	325.750	325.688	325.750	325.875	325.938	325.813
	588.000	593.375	598.625	604.000	609.313	614.563	619.813	625.188	630.500	635.875
27 42'	319.688	319.688	319.625	319.688	319.688	319.750	319.813	319.938	319.938	319.938
	588.000	593.313	598.688	604.000	609.313	614.688	620.000	625.313	630.563	635.875
27 36'	313.688	313.625	313.813	313.750	313.750	313.813	313.750	313.813	313.813	314.000
	587.938	593.313	598.688	604.000	609.313	614.625	620.000	625.250	630.625	635.938
27 30'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 24'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 18'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 12'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 6'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 4. EDARC X-Y POSITION IN MILES
AT 1000 FEET ALTITUDE (CONTINUED)

	93 0'	92 54'	92 48'	92 42'	92 36'	92 30'	92 24'	92 18'	92 12'	92 6'
29 0'	397.625 640.500	397.625 645.813	397.750 650.875	397.750 656.188	397.875 661.500	397.875 666.750	398.000 671.875	398.063 677.063	398.125 682.500	398.250 687.750
28 54'	391.625 640.500	391.750 645.750	391.688 651.188	391.813 656.250	391.875 661.500	391.875 666.938	392.000 672.063	392.063 677.250	392.250 682.563	392.250 687.813
28 48'	385.688 640.688	385.750 645.875	385.750 651.063	385.938 656.375	385.938 661.688	385.938 666.875	386.063 672.250	386.250 677.250	386.313 682.625	386.375 687.813
28 42'	379.750 640.625	379.750 646.000	379.750 651.125	379.875 656.563	379.938 661.688	380.063 666.938	380.063 672.188	380.188 677.375	380.250 682.688	380.313 688.000
28 36'	373.750 640.688	373.875 646.063	373.875 651.250	374.000 656.563	373.938 661.813	374.063 667.063	374.125 672.313	374.250 677.625	374.313 682.813	374.438 688.188
28 30'	367.813 640.750	367.750 646.063	367.875 651.438	368.000 656.563	368.000 661.875	368.063 667.188	368.125 672.313	368.250 677.688	368.375 682.938	368.375 688.125
28 24'	361.875 640.875	361.875 646.063	362.000 651.438	361.938 656.750	362.063 662.000	362.125 667.250	362.313 672.500	362.313 677.688	362.438 683.063	362.500 688.375
28 18'	355.813 640.938	355.875 646.250	355.938 651.500	355.938 656.813	356.125 662.063	356.188 667.313	356.250 672.563	356.313 677.875	356.375 683.188	356.563 688.500
28 12'	349.813 641.000	349.875 646.313	350.000 651.563	350.000 656.813	350.125 662.125	350.250 667.438	350.313 672.688	350.500 677.938	350.563 683.250	350.688 688.500
28 6'	343.938 640.938	344.000 646.313	343.938 651.563	344.000 656.938	344.188 662.250	344.250 667.500	344.313 672.750	344.438 678.000	344.500 683.375	344.563 688.625
28 0'	337.938 641.000	338.000 646.313	337.938 651.688	338.125 657.000	338.188 662.250	338.188 667.625	338.313 672.813	338.313 678.063	338.563 683.500	338.563 688.813
27 54'	331.875 641.125	332.000 646.500	332.125 651.688	332.063 657.125	332.188 662.375	332.125 667.875	332.375 672.938	332.313 678.563	332.563 683.563	332.125 688.938
27 48'	326.000 641.125	325.875 646.563	326.000 651.750	326.000 657.688	326.188 662.438	326.000 668.250	326.375 673.063	326.125 679.188	326.625 683.688	326.125 689.563
27 42'	320.000 641.188	319.938 646.938	320.125 651.875	320.000 658.063	320.313 662.563	320.125 668.750	320.563 673.188	320.250 679.625	320.625 683.813	319.938 690.250
27 36'	314.063 641.313	313.750 647.188	314.125 652.000	313.813 658.688	314.250 662.625	314.500 673.250	314.500 673.250	314.125 680.125	314.625 683.938	313.875 690.938
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

TABLE 4. EDARC X-Y POSITION IN MILES
AT 1000 FEET ALTITUDE (CONTINUED)

	92 0'	91 54'	91 48'	91 42'	91 36'	91 30'	91 24'	91 18'	91 12'	91 6'
29 0'	398.375	398.438	398.563	398.688	398.875	399.000	399.063	399.188	399.250	399.438
	692.750	698.125	703.375	708.625	713.875	719.125	724.313	729.563	734.750	739.875
28 54'	392.375	392.500	392.563	392.813	392.875	392.938	393.125	393.188	393.438	393.563
	693.063	698.188	703.563	708.688	714.125	719.188	724.438	729.813	734.938	740.125
28 48'	386.500	386.563	386.688	386.813	386.813	387.063	387.125	387.250	387.313	387.563
	693.000	698.313	703.688	708.813	714.188	719.375	724.625	729.813	735.125	740.313
28 42'	380.563	380.625	380.688	380.875	380.938	381.125	381.125	381.250	381.375	381.563
	693.313	698.563	703.688	709.000	714.313	719.500	724.750	730.063	735.313	740.500
28 36'	374.500	374.688	374.750	374.813	375.000	375.125	375.250	375.375	375.500	375.688
	693.250	698.688	703.875	709.125	714.313	719.688	725.000	730.063	735.375	740.688
28 30'	368.500	368.625	368.813	368.938	369.000	369.188	369.250	369.375	369.500	369.688
	693.500	698.750	703.938	709.375	714.438	719.813	725.125	730.313	735.688	740.813
28 24'	362.563	362.750	362.813	362.938	363.063	363.188	363.313	363.438	363.500	363.750
	693.625	698.875	704.188	709.500	714.563	719.875	725.250	730.375	735.750	741.063
28 18'	356.563	356.688	356.938	357.000	357.125	357.188	357.313	357.438	357.563	357.813
	693.750	699.000	704.250	709.625	714.813	720.063	725.375	730.625	735.938	741.313
28 12'	350.750	350.688	350.875	351.000	351.188	351.250	351.375	351.500	351.688	351.813
	693.875	699.125	704.375	709.625	714.938	720.313	725.500	730.750	736.125	741.313
28 6'	344.688	344.938	344.938	345.063	345.188	345.313	345.438	345.500	345.625	345.813
	693.875	699.188	704.563	709.813	715.063	720.438	725.750	730.938	736.188	741.563
28 0'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 54'	0.000	0.000	0.000	0.000	0.000	333.313	333.500	333.625	333.750	333.938
	0.000	0.000	0.000	0.000	0.000	720.688	726.063	731.250	736.625	741.938
27 48'	326.813	326.938	327.000	327.188	327.250	327.375	327.500	327.688	327.813	328.000
	694.313	699.563	704.938	710.250	715.563	720.813	726.188	731.500	736.813	742.125
27 42'	320.813	320.938	321.063	321.250	321.313	321.375	321.563	321.688	321.875	322.000
	694.500	699.750	705.000	710.438	715.688	721.000	726.313	731.625	737.000	742.313
27 36'	314.875	315.000	315.188	315.250	315.313	315.500	315.563	315.750	315.813	316.063
	694.563	699.875	705.250	710.500	715.813	721.250	726.563	731.750	737.125	742.438
27 30'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 24'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 18'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 12'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 6'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 4. EDARC X-Y POSITION IN MILES AT 1000 FEET ALTITUDE (CONTINUED)

	91 0'	90 54'	90 48'	90 42'	90 36'	90 30'	90 24'	90 18'	90 12'	90 6'
29 0'	399.688 745.250	399.813 750.438	399.875 755.688	400.063 761.000	400.250 766.125	400.438 771.438	400.563 776.688	0.000 0.000	0.000 0.000	0.000 0.000
28 54'	393.625 745.438	393.813 750.563	394.000 755.813	394.250 761.000	394.313 766.375	394.375 771.625	394.688 776.813	0.000 0.000	0.000 0.000	0.000 0.000
28 48'	387.750 745.625	387.938 750.813	387.938 756.125	388.250 761.375	388.375 766.625	388.563 771.813	388.750 776.938	0.000 0.000	0.000 0.000	0.000 0.000
28 42'	381.688 745.813	381.875 751.000	382.000 756.313	382.125 761.563	382.313 766.750	382.563 772.000	382.813 777.125	0.000 0.000	0.000 0.000	0.000 0.000
28 36'	375.813 746.000	376.000 751.250	376.188 756.438	376.375 761.688	376.563 766.938	376.563 772.188	376.875 777.438	0.000 0.000	0.000 0.000	0.000 0.000
28 30'	369.750 746.125	370.000 751.375	370.250 756.625	370.313 761.938	370.625 767.188	370.625 772.438	370.938 777.563	0.000 0.000	0.000 0.000	0.000 0.000
28 24'	363.813 746.375	364.125 751.563	364.250 756.875	364.375 762.125	364.625 767.375	364.625 772.625	365.063 777.875	0.000 0.000	0.000 0.000	0.000 0.000
28 18'	357.875 746.438	358.063 751.750	358.313 757.000	358.438 762.313	358.625 767.438	358.750 772.875	358.938 778.188	0.000 0.000	0.000 0.000	0.000 0.000
28 12'	352.000 746.625	352.188 751.875	352.250 757.313	352.500 762.500	352.625 767.813	352.813 773.000	353.063 778.438	0.000 0.000	0.000 0.000	0.000 0.000
28 6'	346.000 746.875	346.250 752.063	346.250 757.438	346.563 762.688	346.688 768.063	346.875 773.188	347.125 778.563	0.000 0.000	0.000 0.000	0.000 0.000
28 0'	340.000 747.063	340.188 752.313	340.375 757.563	340.500 762.875	340.688 768.125	341.000 773.500	341.125 778.750	0.000 0.000	0.000 0.000	0.000 0.000
27 54'	334.063 747.188	334.250 752.500	334.375 757.813	334.625 763.063	334.750 768.375	334.938 773.750	335.125 779.000	0.000 0.000	0.000 0.000	0.000 0.000
27 48'	328.188 747.375	328.250 752.750	328.438 757.938	328.625 763.313	328.750 768.688	328.938 774.000	329.188 779.250	0.000 0.000	0.000 0.000	0.000 0.000
27 42'	322.125 747.625	322.313 752.938	322.438 758.313	322.625 763.500	322.813 768.813	323.063 774.125	323.250 779.375	0.000 0.000	0.000 0.000	0.000 0.000
27 36'	316.125 747.813	316.375 753.125	316.500 758.438	316.750 763.688	316.938 768.938	317.063 774.313	317.313 779.563	0.000 0.000	0.000 0.000	0.000 0.000
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

TABLE 5. EDARC X-Y POSITION IN MILES
AT 4900 FEET ALTITUDE

Lat \ Lon --> Deg Min	96 00'	95 54'	95 48'	95 42'	95 36'	95 30'	95 24'	95 18'	95 12'	95 6'
29 0'	0.000 0.000	0.000 0.000	398.375 493.563	398.375 498.688	398.125 503.938	398.125 509.188	397.938 514.563	397.938 519.813	397.938 525.063	397.750 530.250
28 54'	0.000 0.000	0.000 0.000	392.563 493.438	392.375 498.688	392.250 503.938	392.250 509.188	392.063 514.500	391.938 519.750	391.875 524.938	391.938 530.313
28 48'	0.000 0.000	0.000 0.000	386.375 493.188	386.375 498.563	386.188 503.813	386.250 509.125	386.188 514.438	386.063 519.563	385.938 524.938	385.875 530.063
28 42'	0.000 0.000	0.000 0.000	380.375 493.125	380.375 498.438	380.250 503.688	380.125 508.938	380.125 514.188	380.000 519.375	380.000 524.813	379.875 529.938
28 36'	0.000 0.000	0.000 0.000	374.500 493.063	374.375 498.250	374.313 503.625	374.188 508.750	374.125 514.188	374.063 519.438	374.000 524.813	374.000 530.125
28 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 0'	0.000 0.000	0.000 0.000	338.563 492.375	338.563 497.688	338.438 502.938	338.250 508.250	338.188 513.625	338.125 518.875	338.000 524.250	337.875 529.563
27 54'	0.000 0.000	0.000 0.000	332.750 492.313	332.563 497.625	332.313 502.813	332.250 508.188	332.313 513.563	332.250 518.875	332.125 524.188	332.063 529.563
27 48'	0.000 0.000	0.000 0.000	326.625 492.188	326.625 497.500	326.500 502.813	326.250 508.063	326.188 513.438	326.250 518.875	326.000 524.063	326.125 529.438
27 42'	0.000 0.000	0.000 0.000	0.000 0.000	320.500 497.375	320.500 502.750	320.438 508.063	320.188 513.313	320.188 518.750	320.063 524.063	320.125 529.313
27 36'	0.000 0.000	0.000 0.000	0.000 0.000	314.500 497.313	314.375 502.625	314.188 507.938	314.125 513.188	314.188 518.625	314.000 524.000	313.938 529.313
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

Entry Format: x.xxx - system y coordinate
x.xxx - system x coordinate

TABLE 5. EDARC X-Y POSITION IN MILES AT 4900 FEET ALTITUDE (CONTINUED)

	95 0'	94 54'	94 48'	94 42'	94 36'	94 30'	94 24'	94 18'	94 12'	94 6'
29 0'	397.688	397.750	397.750	397.625	397.563	397.625	397.563	397.375	397.563	397.500
	535.500	540.875	546.125	551.313	556.563	561.938	567.188	572.250	577.625	582.813
28 54'	391.938	391.750	391.750	391.625	391.563	391.563	391.500	391.438	391.625	391.500
	535.563	540.750	546.000	551.188	556.500	561.750	567.000	572.250	577.563	582.813
28 48'	385.813	385.625	385.625	385.688	385.625	385.688	385.563	385.500	385.563	385.500
	535.375	540.625	545.875	551.313	556.500	561.875	567.000	572.313	577.563	582.750
28 42'	379.875	379.750	379.750	379.813	379.688	379.625	379.625	379.563	379.563	379.438
	535.313	540.563	545.875	551.188	556.563	561.625	567.063	572.250	577.500	582.688
28 36'	373.813	373.750	373.688	373.688	373.750	373.625	373.688	373.625	373.563	373.563
	535.188	540.438	545.875	551.000	556.438	561.625	566.938	572.188	577.563	582.750
28 30'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28 24'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28 18'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28 12'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28 6'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28 0'	337.938	337.938	337.875	337.875	337.688	337.750	337.688	337.813	337.688	337.688
	534.813	540.250	545.563	550.813	556.125	561.438	566.688	572.125	577.313	582.688
27 54'	331.875	331.813	331.813	331.750	331.688	331.813	331.688	331.563	331.750	331.688
	534.813	540.125	545.438	550.688	556.000	561.438	566.688	572.063	577.500	582.750
27 48'	326.063	325.938	325.813	325.875	325.938	325.750	325.688	325.750	325.625	325.625
	534.750	540.063	545.438	550.813	556.063	561.438	566.625	572.063	577.250	582.688
27 42'	319.938	319.938	319.750	319.938	319.875	319.750	319.750	319.813	319.750	319.813
	534.688	540.000	545.375	550.688	556.063	561.313	566.688	572.063	577.438	582.688
27 36'	314.000	313.875	313.938	313.750	313.750	313.688	313.688	313.688	313.688	313.688
	534.625	540.000	545.375	550.688	556.000	561.313	566.688	571.938	577.375	582.625
27 30'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 24'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 18'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 12'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27 6'	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 5. EDARC X-Y POSITION IN MILES
AT 4900 FEET ALTITUDE (CONTINUED)

	94 0'	93 54'	93 48'	93 42'	93 36'	93 30'	93 24'	93 18'	93 12'	93 6'
29 0'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 54'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 48'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 42'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 36'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 30'	367.563 588.000	367.625 593.250	367.563 598.625	367.625 603.875	367.625 609.188	367.625 614.500	367.688 619.750	367.625 625.000	367.688 630.250	367.750 635.500
28 24'	361.563 587.938	361.563 593.250	361.500 598.438	361.625 603.875	361.625 609.063	361.625 614.375	361.688 619.688	361.688 625.000	361.625 630.250	361.813 635.625
28 18'	355.625 588.000	355.563 593.188	355.625 598.625	355.625 603.938	355.688 609.188	355.750 614.375	355.688 619.813	355.750 625.063	355.813 630.250	355.813 635.625
28 12'	349.750 588.000	349.625 593.313	349.688 598.563	349.625 603.938	349.563 609.188	349.750 614.438	349.688 619.813	349.813 625.063	349.813 630.313	349.875 635.625
28 6'	343.688 588.125	343.625 593.250	343.688 598.625	343.688 603.875	343.688 609.188	343.688 614.375	343.750 619.813	343.750 625.188	343.750 630.375	343.875 635.750
28 0'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 54'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 48'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 42'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 36'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

TABLE 5. EDARC X-Y POSITION IN MILES AT 4900 FEET ALTITUDE (CONTINUED)

	93 0'	92 54'	92 48'	92 42'	92 36'	92 30'	92 24'	92 18'	92 12'	92 6'
29 0'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 54'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 48'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 42'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 36'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 30'	367.813 640.750	367.750 646.063	367.938 651.375	368.000 656.563	368.000 661.875	368.063 667.188	368.250 672.313	368.250 677.688	368.375 682.938	368.500 688.125
28 24'	361.875 640.875	361.875 646.063	362.000 651.438	361.938 656.750	362.063 662.000	362.125 667.250	362.313 672.500	362.313 677.688	362.438 683.063	362.500 688.375
28 18'	355.813 640.938	355.875 646.250	355.938 651.500	355.938 656.813	356.125 662.063	356.188 667.313	356.250 672.563	356.313 677.875	356.375 683.188	356.563 688.500
28 12'	349.938 640.938	350.000 646.313	350.000 651.563	350.000 656.813	350.125 662.125	350.250 667.438	350.313 672.688	350.500 677.938	350.563 683.250	350.688 688.500
28 6'	343.938 640.938	344.000 646.313	344.063 651.500	344.000 656.938	344.188 662.250	344.250 667.500	344.313 672.750	344.438 678.000	344.500 683.375	344.563 688.625
28 0'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 54'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 48'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 42'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 36'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

TABLE 5. EDARC X-Y POSITION IN MILES AT 4900 FEET ALTITUDE (CONTINUED)

	92 0'	91 54'	91 48'	91 42'	91 36'	91 30'	91 24'	91 18'	91 12'	91 6'
29 0'	398.375 692.750	398.438 698.125	398.563 703.375	398.688 708.625	398.875 713.875	399.000 719.125	399.063 724.313	399.188 729.563	399.250 734.750	399.438 739.875
28 54'	392.375 693.063	392.500 698.188	392.563 703.563	392.813 708.688	392.875 714.125	392.938 719.188	393.125 724.438	393.188 729.813	393.438 734.938	393.563 740.125
28 48'	386.500 693.000	386.563 698.313	386.688 703.688	386.813 708.813	386.813 714.188	387.063 719.375	387.125 724.625	387.250 729.813	387.313 735.125	387.563 740.313
28 42'	380.563 693.313	380.625 698.563	380.688 703.688	380.875 709.000	380.938 714.313	381.125 719.500	381.125 724.750	381.250 730.063	381.375 735.313	381.563 740.500
28 36'	374.500 693.250	374.688 698.688	374.750 703.875	374.813 709.125	375.000 714.313	375.125 719.688	375.250 725.000	375.375 730.063	375.500 735.375	375.688 740.688
28 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 0'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 54'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 48'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 42'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 36'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

TABLE 5. EDARC X-Y POSITION IN MILES AT 4900 FEET ALTITUDE (CONTINUED)

	91 0'	90 54'	90 48'	90 42'	90 36'	90 30'	90 24'	90 18'	90 12'	90 6'
29 0'	399.688 745.250	399.813 750.438	399.875 755.688	400.063 761.000	400.250 766.125	400.438 771.438	400.563 776.688	0.000 0.000	0.000 0.000	0.000 0.000
28 54'	393.625 745.438	393.813 750.563	394.000 755.813	394.125 760.938	394.313 766.375	394.375 771.625	394.688 776.813	0.000 0.000	0.000 0.000	0.000 0.000
28 48'	387.750 745.625	387.938 750.813	387.938 756.125	388.125 761.250	388.375 766.625	388.563 771.813	388.750 776.938	0.000 0.000	0.000 0.000	0.000 0.000
28 42'	381.688 745.813	381.875 751.000	382.000 756.313	382.125 761.563	382.313 766.750	382.563 772.000	382.813 777.125	0.000 0.000	0.000 0.000	0.000 0.000
28 36'	375.813 746.000	375.875 751.188	376.063 756.375	376.375 761.688	376.563 766.938	376.563 772.188	376.875 777.438	0.000 0.000	0.000 0.000	0.000 0.000
28 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
28 0'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 54'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 48'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 42'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 36'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 30'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 24'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 18'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 12'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
27 6'	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000

Table 6 shows that a worst case occurs in the difference between system x mean error, with long held constant, for altitudes of 1000 and 4900 feet. The difference of 0.03 nmi corresponds approximately to a difference of 180 feet as displayed to the controller. This difference is below the display resolution of 1/32 nmi of the PVD. A variation of this magnitude, which results from altitude differences for targets at the same lat/long will, therefore, be indiscernible on the display.

TABLE 6. EDARC VARIATION IN NAUTICAL MILES

	Constant Mean	Latitude SD	Constant Mean	Longitude SD
Altitude: 1000 feet				
System-x	0.03880	0.13680	5.97546	0.08900
System-y	5.29000	0.33776	-0.06193	0.22505
Altitude: 4900 feet				
System-x	0.02498	0.11552	5.97805	0.09206
System-y	5.28056	0.08919	-0.02719	0.12599
Altitude: 100 feet				
System-x	0.04418	0.11975	5.97285	0.08603
System-y	5.28336	0.07983	-0.05031	0.13249

Statistics on EDARC conversion accuracy are influenced by several effects. One results from the fact that the local orientation of the system plane is not coincident with the local orientation of true north, used in lat long. This has the effect of an angular displacement of the data, whereby latitude does not correspond exactly with system y coordinates and longitude does not correspond exactly with x coordinates. The result will be a slight increase in the variation (both mean and standard deviation) of the data. This effect has not been accounted for in the data reduction because it is small in magnitude and does not affect the relative performance of the conversion process in a local area (i.e., local effects are the same for any two or more targets in the same area and have no influence on determining the separation between them).

A second effect which occurs in the transformation from lat/long to system x-y is that of converting the angular distance of lat/long in degrees into linear distance, in miles, on the surface of the Earth. This also results in a slight skewing of the statistics when comparing the two. As before, the effect occurs over a large area and will only be noticeable in statistics for the entire LOFF area. Local separation will not be affected.

EDARC DYNAMIC ACCURACY.

Static accuracy tests, as described above, were used to determine EDARC conversion accuracy and provide a basis for measurement of dynamic accuracy. It is this dynamic measure which provides a truer indication of performance while the system tracks actual aircraft. The difference between static and dynamic accuracy results from the influence of the tracker function in the EDARC system.

The output of the tracker-predicted position is displayed to the controller and used for separation purposes. It may be noted once again that the primary purpose of these tests was not to measure EDARC performance because it is a commissioned system. The purpose was to show the contribution of EDARC conversion and tracker accuracy to the overall performance of the LOFF system.

Dynamic accuracy was measured by comparing dynamic targets from flight testing with data collected during static simulation tests. The difference between static and dynamic results is attributed to the effects of the tracker function in EDARC. Results are presented in table 7. They show that the tracker influence causes a position shift of 1.1 nmi (mean root sum of squares value) in the displayed track position as compared to the static case. The EDARC data recording system failure noted above caused loss of all this data except for one flight.

TABLE 7. EDARC DYNAMIC ACCURACY IN NAUTICAL MILES

	Mean	Standard Deviation	Samples
Latitude	0.60	0.53	88
Longitude	0.89	0.61	88

The position shift does not appear to be direction dependent. Results are consistent for the eastbound and westbound portions of the flight. It should also be noted that data have not been grouped according to whether they are in the steady-state or accelerated condition. EDARC does not record the types of data required for this kind of analysis. An alpha-beta tracker, such as the one implemented in EDARC, is susceptible to large errors for short periods of time when accelerations due to a turn are encountered.

COMPARATIVE PERFORMANCE IN OVERLAP AREAS.

Table 8 shows the relative differences based upon the EDARC tracked position as displayed to the controller; figure 13 shows the radar and LOFF overlap areas. The amount of this type of data was also reduced due to the failure of EDARC data recording components during the flight test. The table shows that LOFF and radar displayed position differ by 0.4 nmi in lat and 0.7 nmi in long. The root sum of squares (rss) value is 0.8 nmi.

TABLE 8. RADAR-LOFF COMPARISON IN NAUTICAL MILES

	Mean	Standard Deviation	Samples
Latitude	0.40	0.72	43
Longitude	0.68	0.58	43

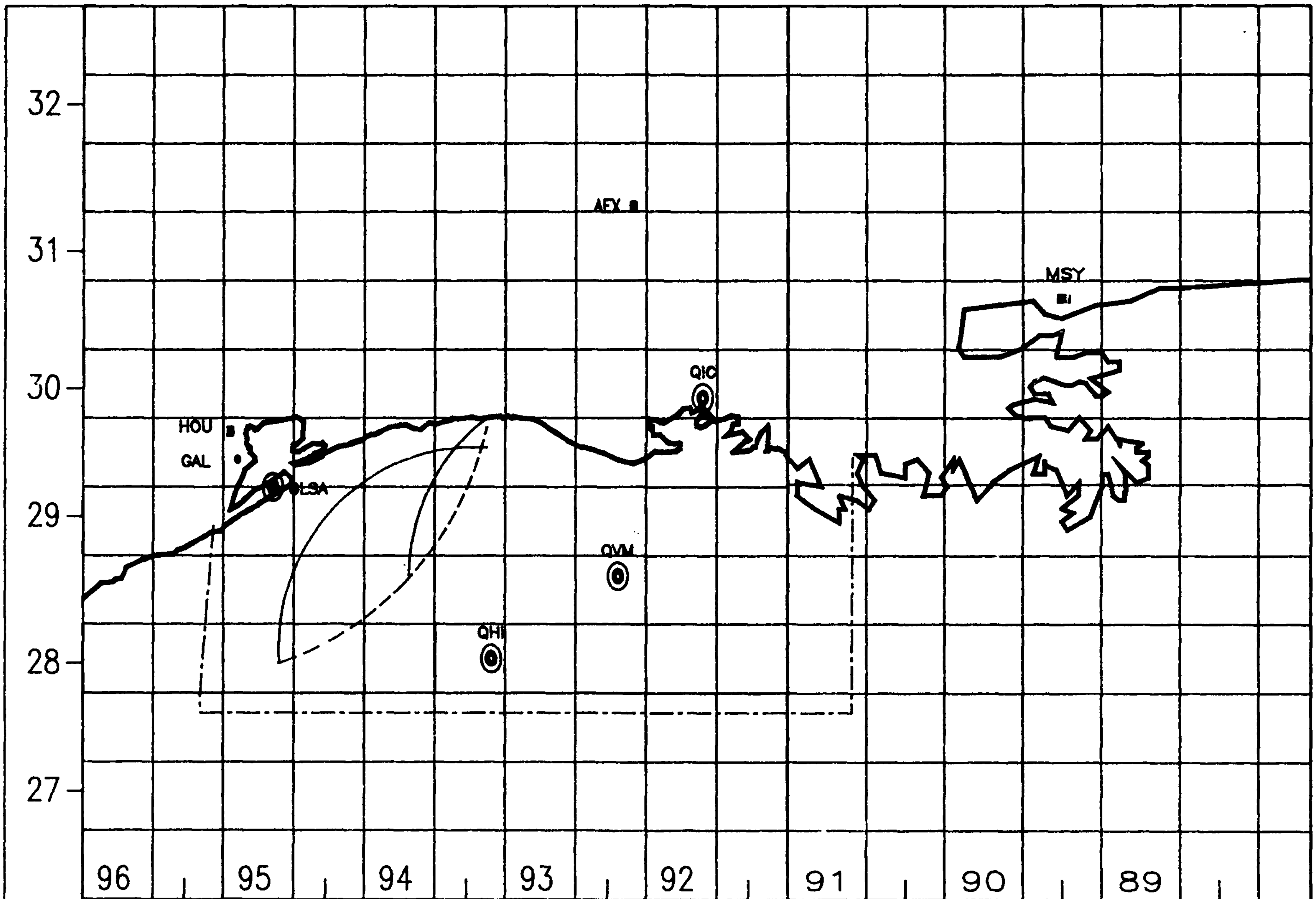

FIGURE 13. RADAR-LOFF OVERLAP AREA AT 5000 FEET ALTITUDE

LORAN ACCURACY.

Tables 9 and 10 show the measured accuracy of both Loran receivers. A difference in performance between the two types of Loran receivers can be seen in the tables. This is due to the difference in technologies employed in their manufacture. The ONI-7000 tracks up to eight stations in four Loran chains. It is, therefore, less dependent upon station geometry than the TDL-711, which includes only three stations in its navigational solution. ONI-7000 data are fairly constant throughout the flight test area. Plots of TDL-711 accuracy are provided in figures 14 through 22. Although most of the data show very small errors, the error increases in the vicinity of Houston, as marked on the plots. This is due to station geometry and is very repeatable. The error does not exceed the limits for en route navigational accuracy as defined in Advisory Circular 90-45A. The statistics in table 10 correspond to these plots, except that outliers have been deleted from the statistics.

TABLE 9. ONI-7000 ACCURACY IN NAUTICAL MILES

	Latitude		Longitude		
Date	Mean	SD	Mean	SD	Samples
9/10/87	0.05	0.05	-0.01	0.04	2307
9/13/87	0.05	0.14	0.01	0.05	3450
9/14/87	0.03	0.08	0.02	0.05	6364
9/15/87	0.03	0.11	0.03	0.04	5128
9/20/87	0.01	0.10	0.03	0.05	3378
9/21/87	0.05	0.18	0.01	0.10	7516
9/22/87	0.04	0.43	0.00	0.18	[illegible]
9/23/87	0.02	0.06	0.04	0.05	[illegible]
9/24/87	0.02	0.06	0.04	0.05	[illegible]

TABLE 10. TDL-711 ACCURACY IN NAUTICAL MILES

	Latitude		Longitude		
Date	Mean	SD	Mean	SD	Samples
9/10/87	-0.22	0.15	-0.16	0.07	4196
9/13/87	-0.24	0.10	-0.16	0.05	7227
9/14/87	-0.17	0.14	-0.15	0.07	12592
9/15/87	-0.15	0.21	-0.12	0.08	10359
9/20/87	-0.18	0.18	-0.08	0.04	7151
9/21/87	-0.36	0.18	-0.09	0.07	15075
9/22/87	-0.12	0.17	-0.14	0.06	12626
9/23/87	-0.13	0.22	-0.09	0.05	5773
9/24/87	-0.15	0.26	-0.07	0.06	5906

VHF DATA LINK COVERAGE.

Results of the data link coverage tests are presented in figures 23 through 25 and table 11. The figure shows a map of the LOFF sector with the areas of data link coverage superimposed. The coverage pattern as shown on the plot reflects the directional nature of the QVM site.

TDL-711 RADIAL POSITION ERROR VS. TIME
FLIGHT DATE: 09/10/87

DATA PROCESSED BY THE FAA TECHNICAL CENTER
ATLANTIC CITY AIRPORT, N J 08405

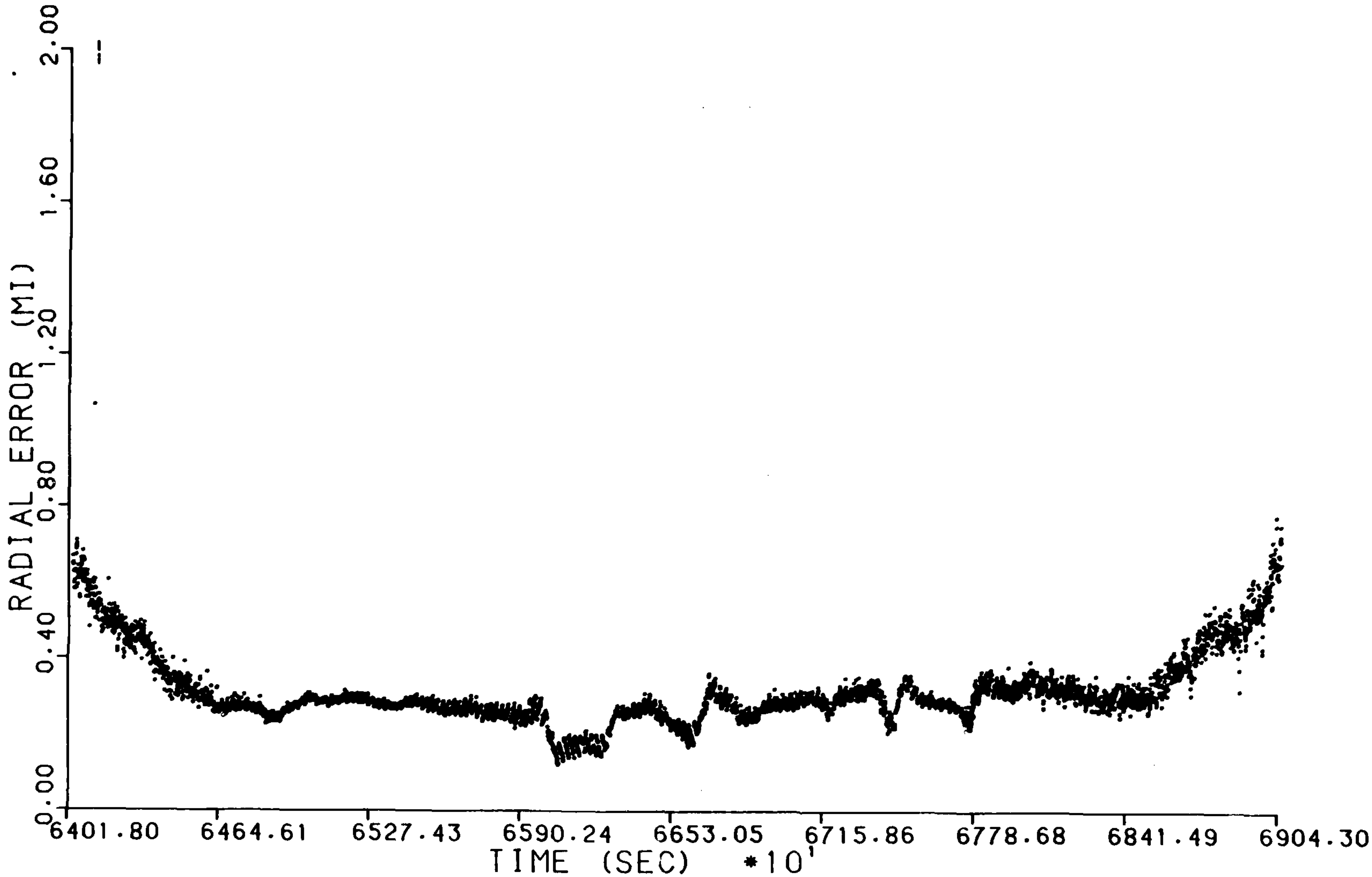

FIGURE 14. TDL-711 RADIAL ERROR - 9/10/87

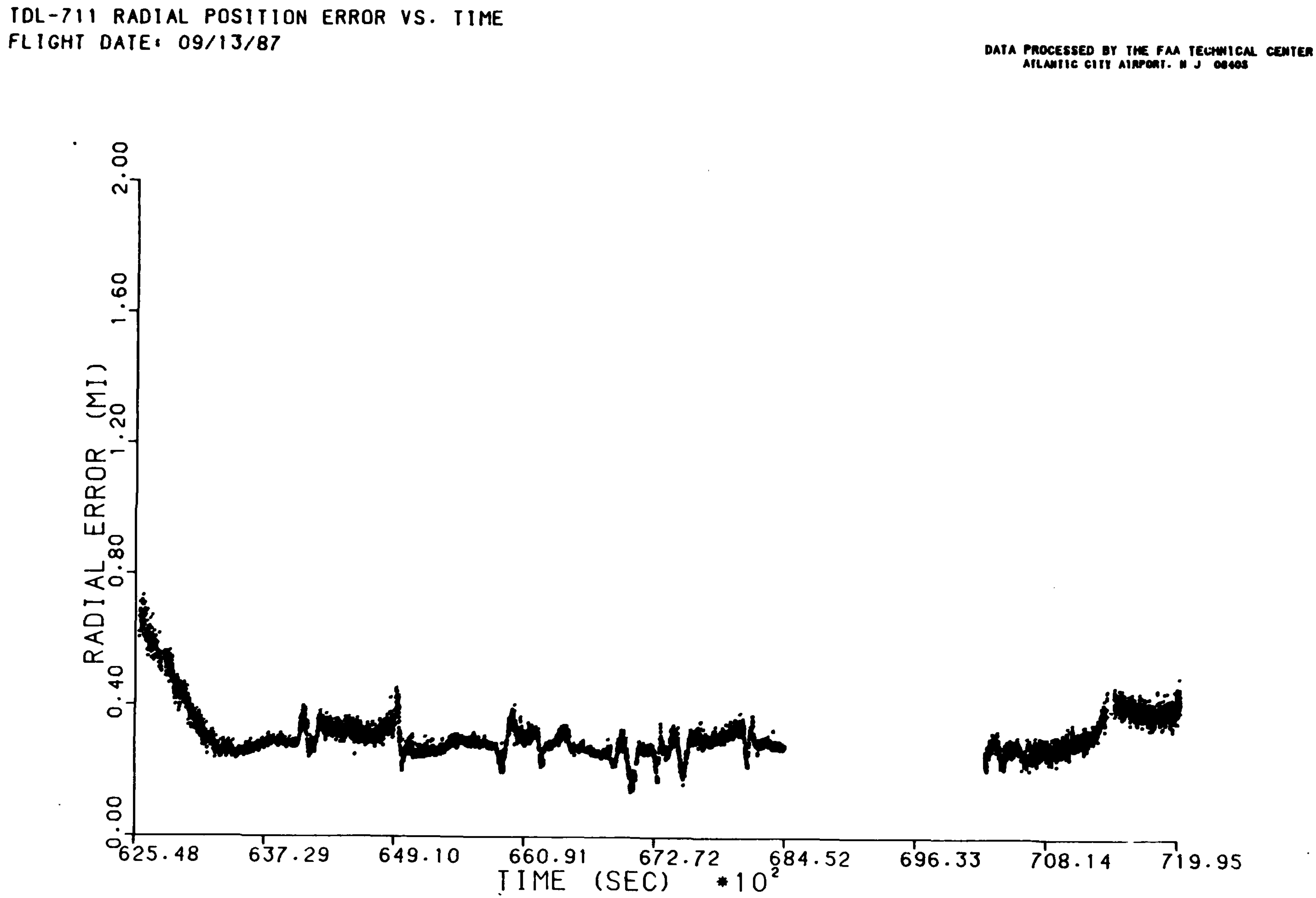

FIGURE 15. TDL-711 RADIAL ERROR - 9/13/87

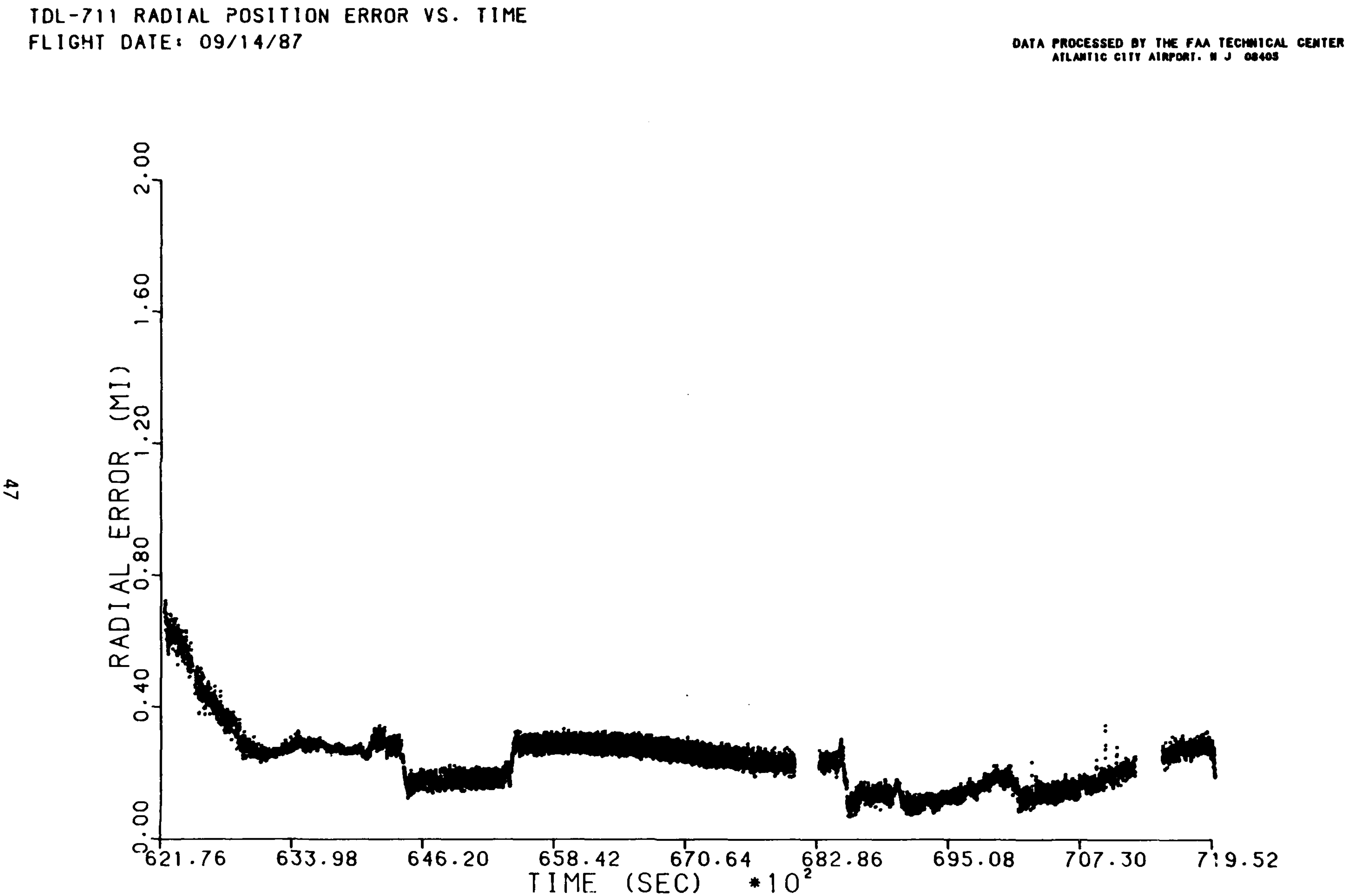

FIGURE 16. TDL-711 RADIAL ERROR - 9/14/87

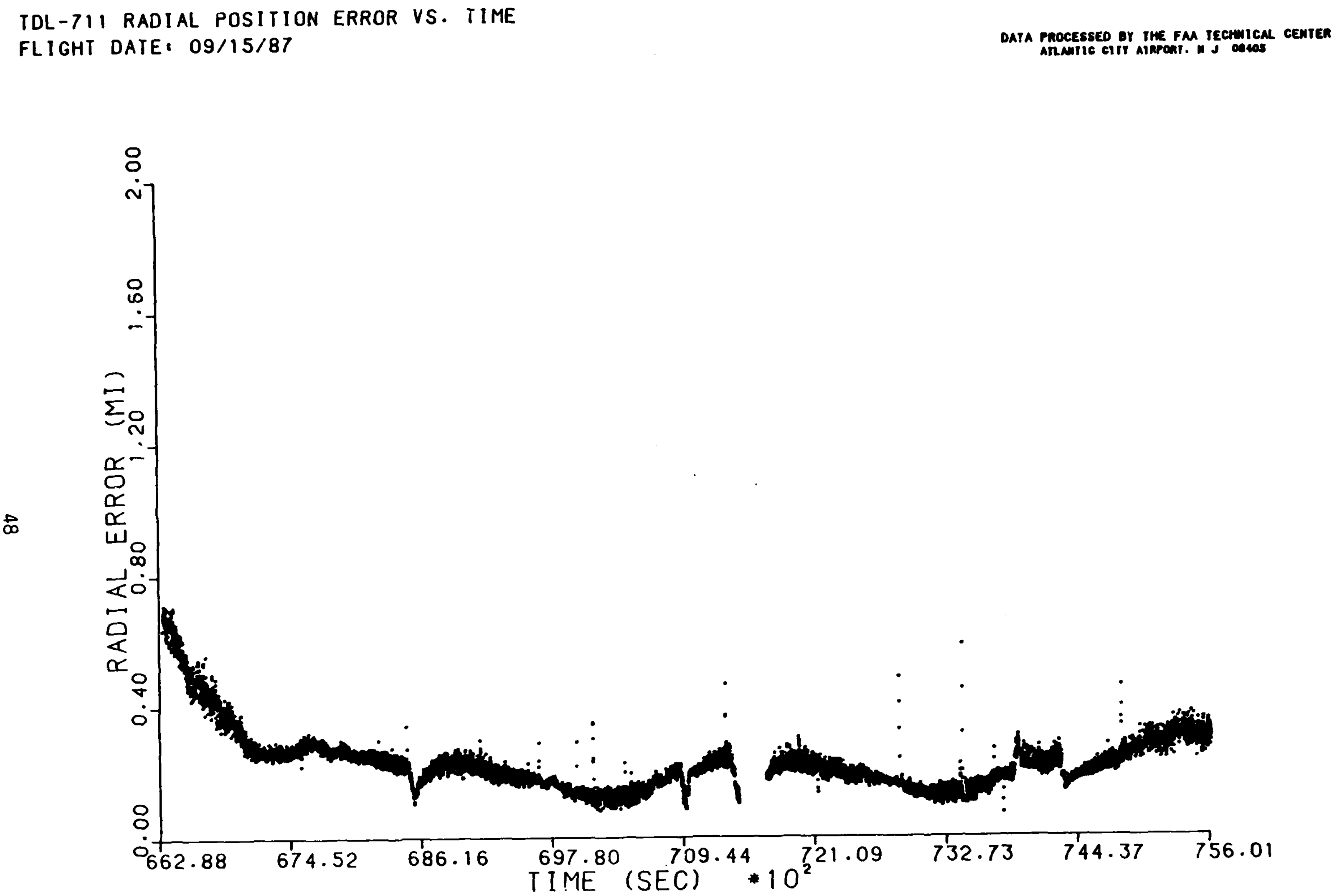

FIGURE 17. TDL-711 RADIAL ERROR - 9/15/87

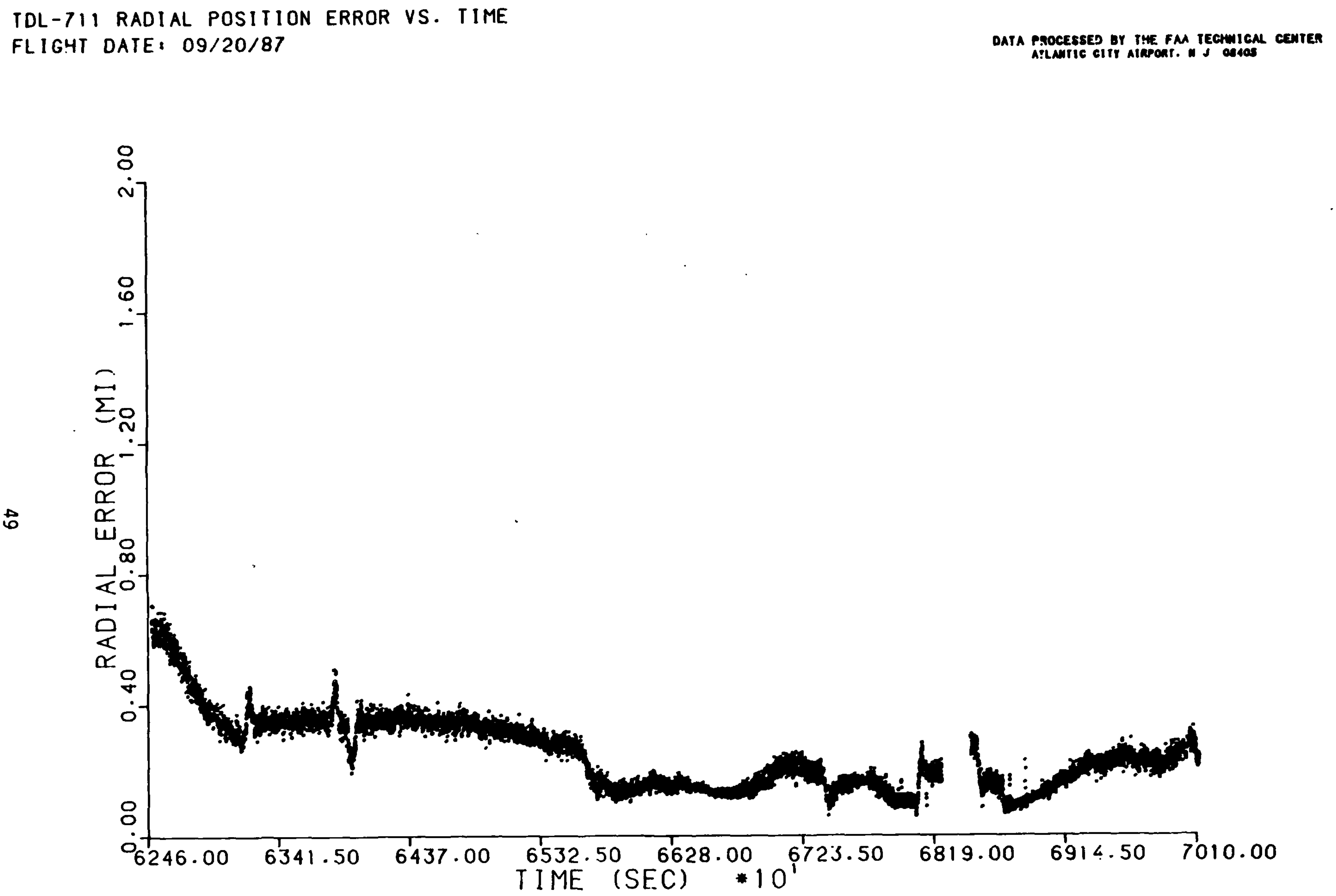

FIGURE 18. TDL-711 RADIAL ERROR - 9/20/87

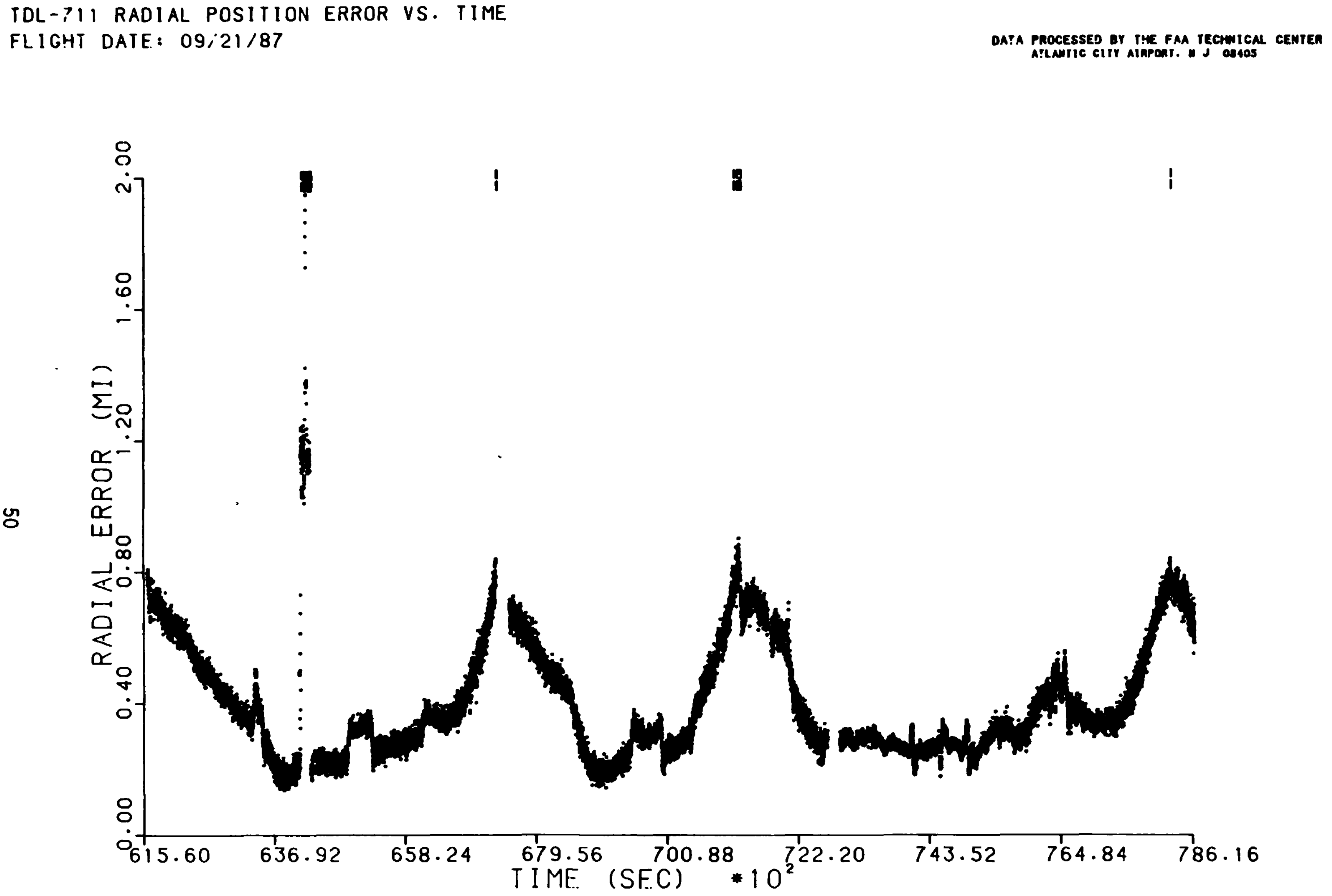

FIGURE 19. TDL-711 RADIAL ERROR - 9/21/87

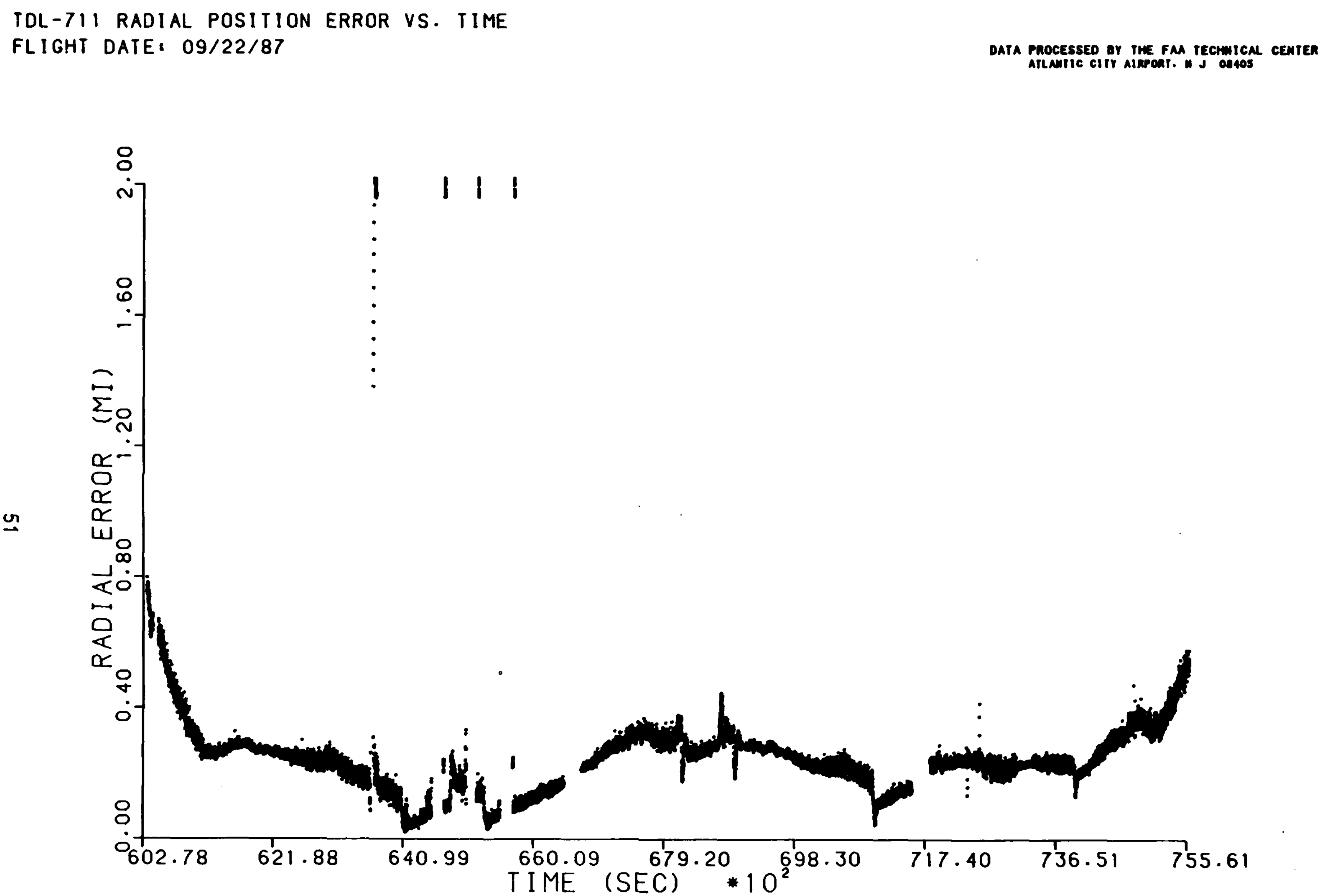

FIGURE 20. TDL-711 RADIAL ERROR - 9/22/87

TDL-711 RADIAL POSITION ERROR VS. TIME
FLIGHT DATE: 09/23/87

DATA PROCESSED BY THE FAA TECHNICAL CENTER
ATLANTIC CITY AIRPORT, N J 08405

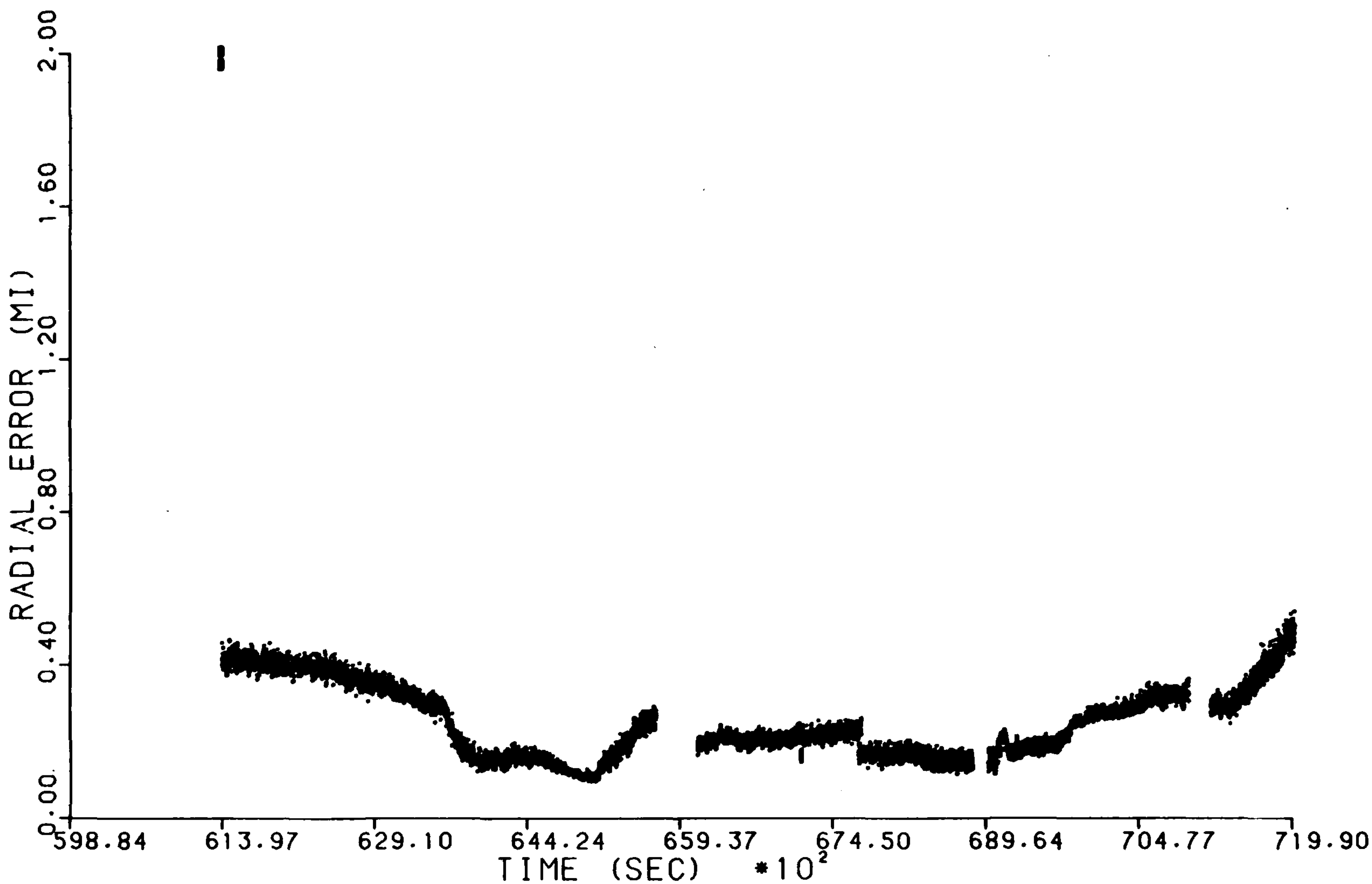

FIGURE 21. TDL-711 RADIAL ERROR - 9/23/87

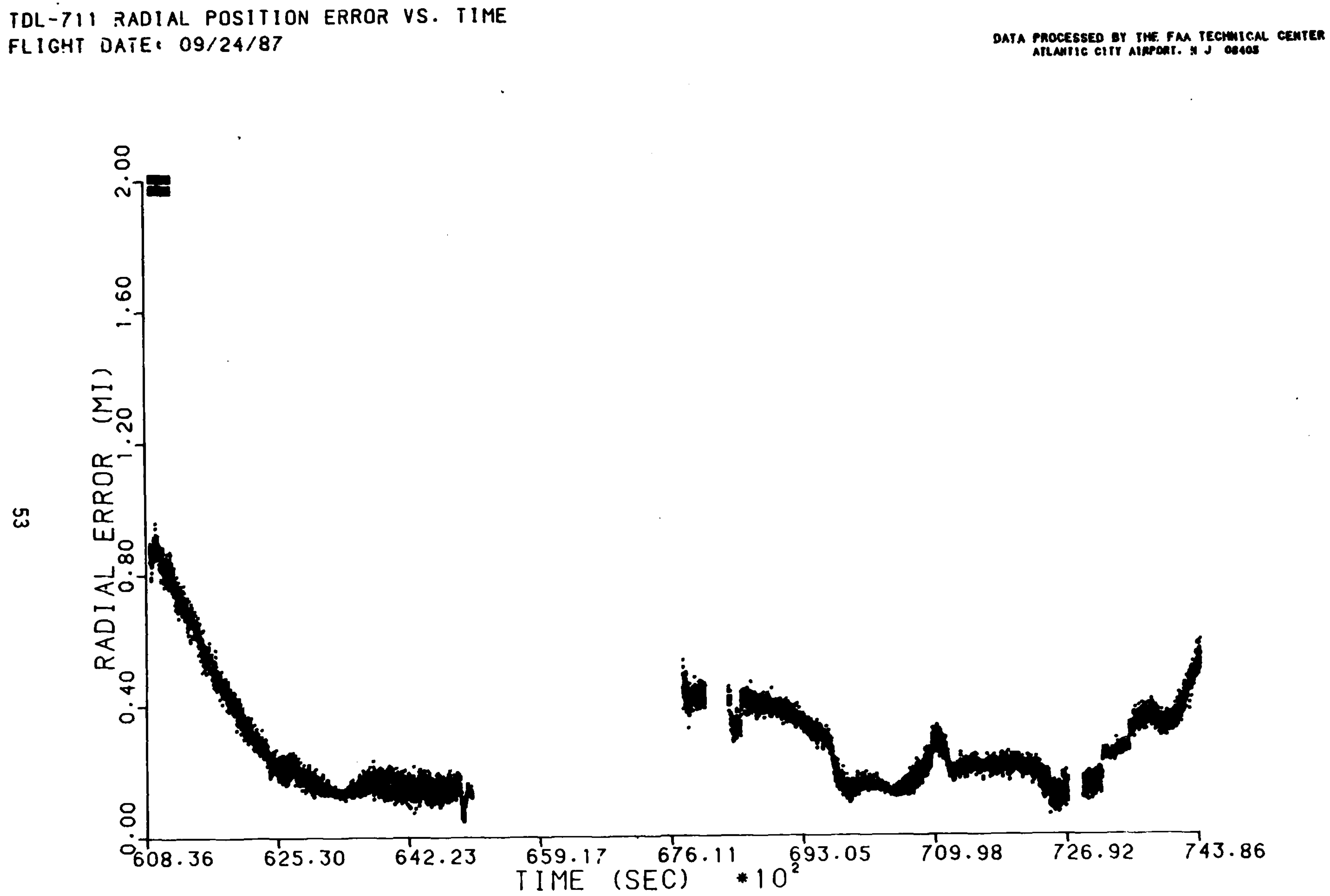

FIGURE 22. TDL-711 RADIAL ERROR - 9/24/87

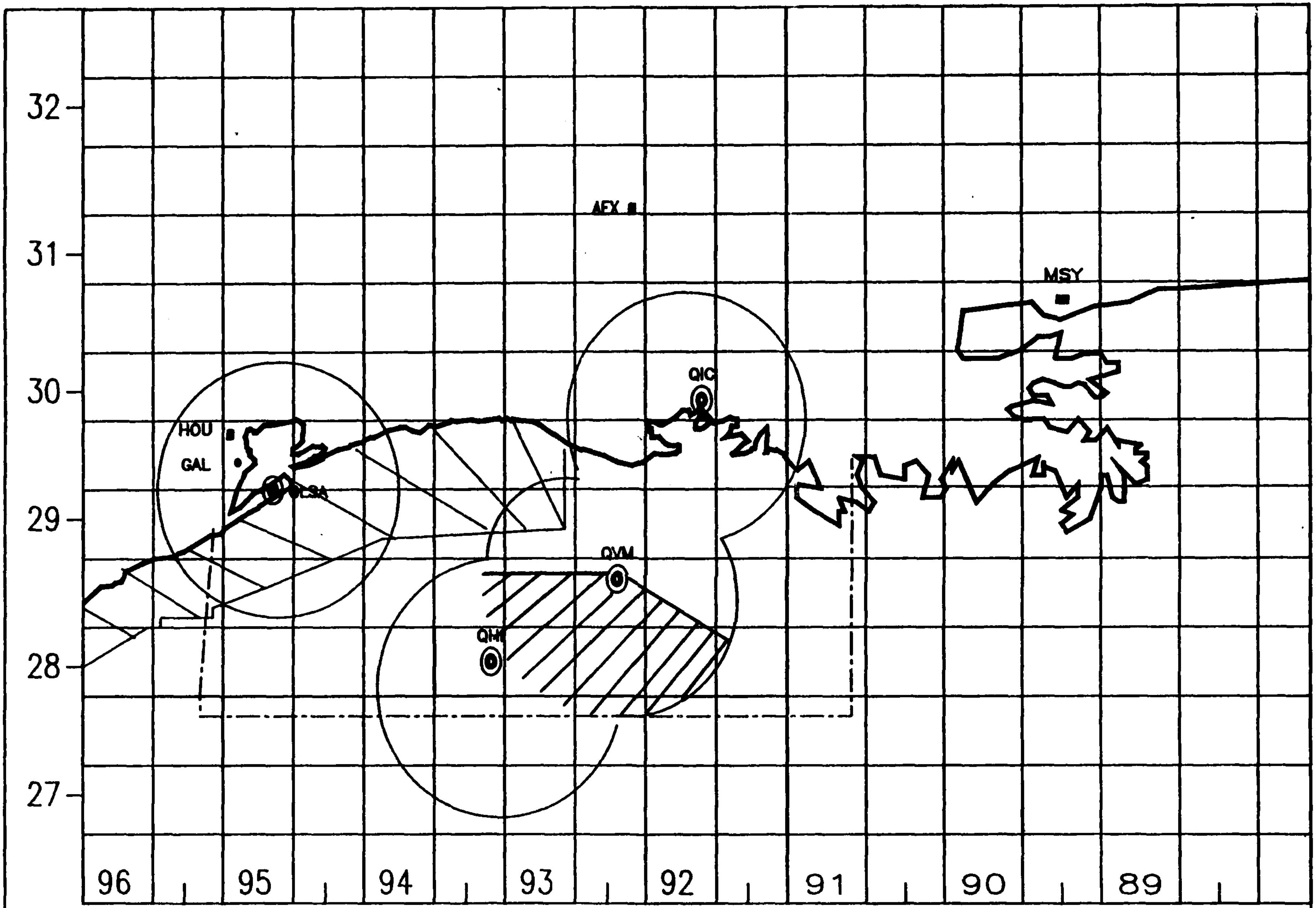

FIGURE 23. LOFF VHF COVERAGE - 1000 FEET ALTITUDE

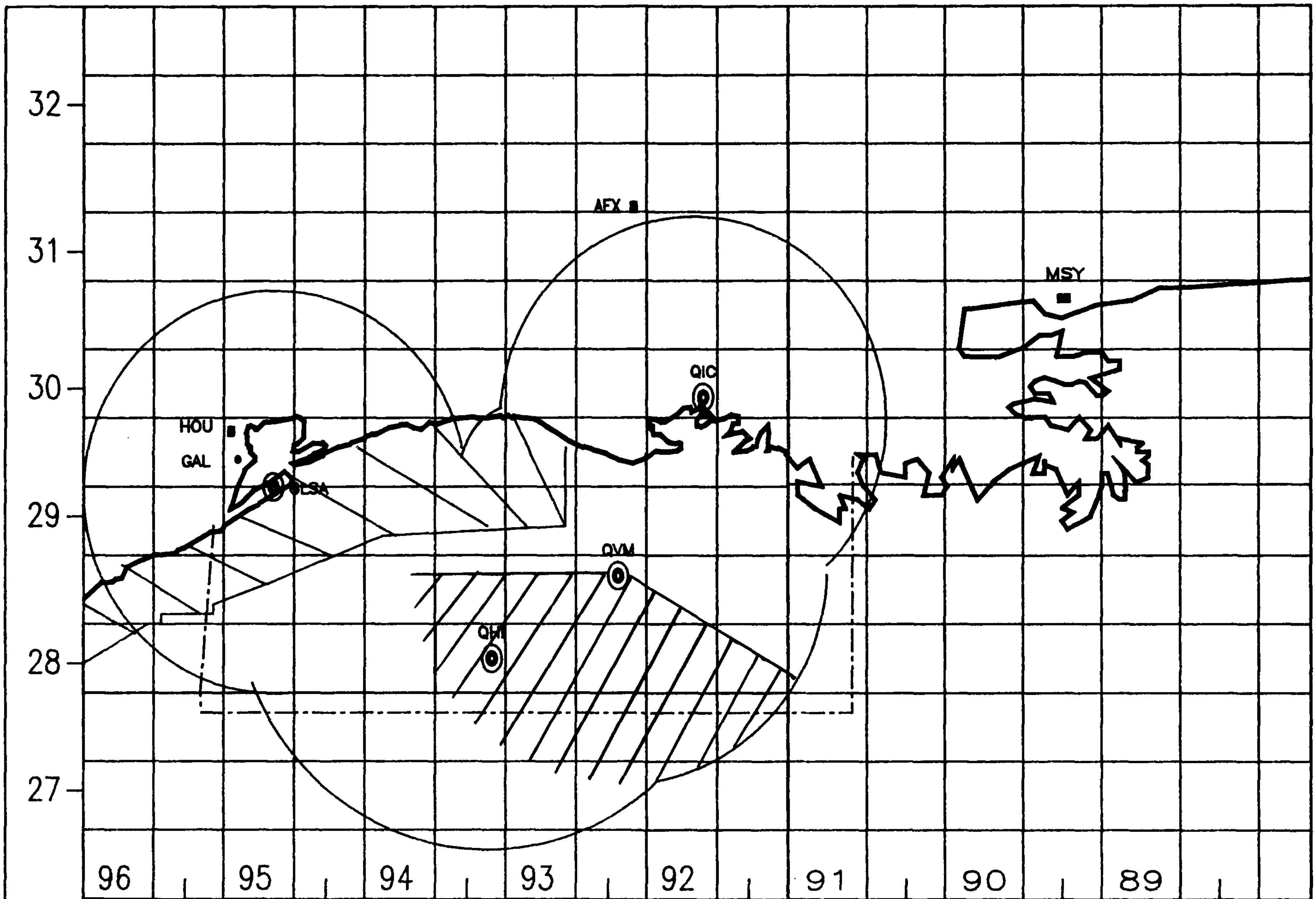

FIGURE 24. LOFF VHF COVERAGE - 3000 FEET ALTITUDE

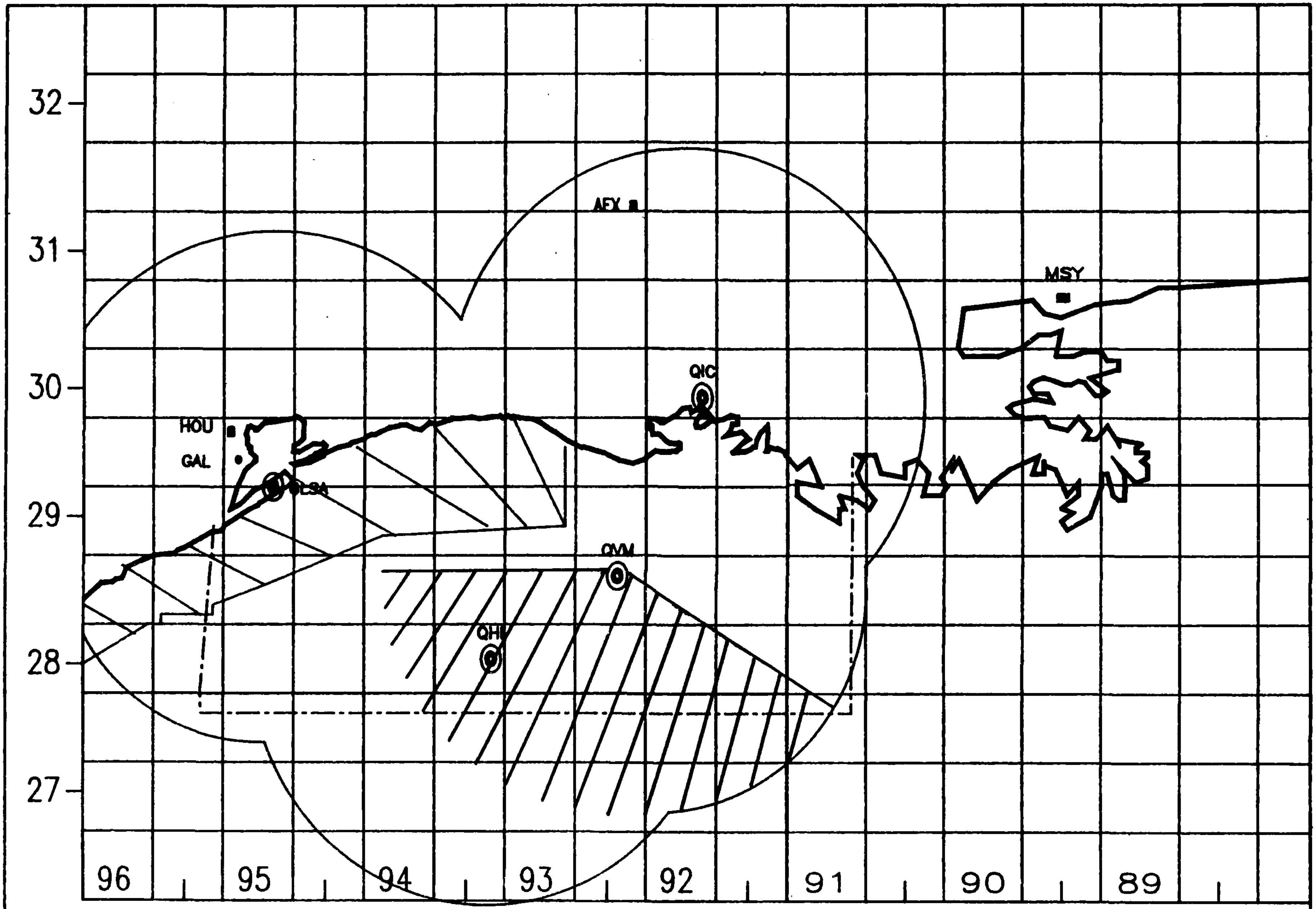

FIGURE 25. LOFF VHF COVERAGE - 5000 FEET ALTITUDE

TABLE 11. LOFF RADIAL COVERAGE IN NAUTICAL MILES

Site	Minimum Coverage	Maximum Coverage	Average
GLSA			
5000 feet	105	112	109
3000 feet	85	98	93
1000 feet	58	62	60
QVM			
5000 feet	110	118	112
3000 feet	85	87	86
1000 feet	52	62	58
QIC			
5000 feet	99	117	105
3000 feet	76	85	81
1000 feet	50	53	52
QHI			
5000 feet	99	100	99
3000 feet	62	98	82
1000 feet	48	60	53

HIGH ALTITUDE PROBE.

The high altitude probe was flown to approximately 26° of lat at flight level 200. The aircraft remained in coverage of the QHI site for the entire time, well beyond the coverage limits of long range radars.

TIME DELAYS.

Time delays as measured by the Infotec converter are shown statistically in table 12. Delays averaged 0.11 seconds. No delays greater than 1 second were observed.

TABLE 12. INFOTEC CONVERTER TIMING DELAYS

Delay Mean	Delay Standard Deviation	Total Samples
0.11 seconds	0.15 seconds	91204

Data link delays are on the order of 0.002 seconds. Delays resulting from the avionics were not measured for this test, but have been estimated by the manufacturer to be less than 0.33 seconds. Total delays through the system is, therefore, expected to be less than 0.5 seconds. A 1-second error corresponds to roughly a 400-foot (1/16 nmi) shift in position at 250 knots, ignoring tracker effects. A position shift of this magnitude is virtually undetectable on a PVD. However, the effect of the tracker may be significantly greater. A radar message contains timing information used by the system to determine time of applicability of the radar return. Since this information is not sent from the converter, performance of the tracker and display position projection algorithms will suffer.

OPERATIONAL EVALUATION.

Several issues not related to technical performance of the LOFF system became apparent during testing. These must be addressed in order to make LOFF a system which can be used to provide separation assurance.

The area of greatest concern is the data link. The VHF communications network currently in place will meet the initial requirements of the system. However, there are shortcomings to the use of a single frequency for both communications and data. Any use of the frequency while a LOFF data burst is in progress will corrupt the data being transmitted. Since there is no way for the ATC automation system to request a repeated data burst, no position data will be available from that aircraft until the next report. During the flight test this aspect of system performance was explored by keying an aircraft transmitter while the data burst was in progress. The result was that the data were completely lost for that transmission. Repeating this action for three consecutive position reports caused EDARC to lose the track and place the target on the PVD in coast mode. It is expected that this effect can also be caused by simultaneous transmission of LOFF data bursts by different aircraft. The likelihood of this occurring increases as the number of aircraft in the system increases. The problem is compounded by the fact that the VHF sites share frequencies. This is convenient for communications but increases the probability of data collisions.

Another result of the use of a single channel for voice and data is that each data burst is heard by all pilots and controllers tuned to that frequency. The result is annoying and distracting to those trying to use the frequency. It also leads to garbled voice transmission and the need to repeat voice reports and instructions.

The issues associated with certification of the airborne equipment have not yet been addressed. This must be done before LOFF may be used in an IFR environment. It was noticed during the flight test that turning the airborne LOFF interface on without valid Loran position available will cause the unit to transmit invalid position reports. The ground equipment has no means of determining that these messages are invalid.

Another certification issue involves placement of the antenna on an aircraft. During testing it was noted that data bursts would occasionally be received beyond the point of lost LOFF contact when the aircraft was in a turn. The antenna location used for this test was on top of the aircraft, behind the wing. It is expected that this location is the worst case, and performance may improve for aircraft with a bottom mounted antenna for LOFF use.

The airborne equipment as currently designed allows selection of LOFF codes which correspond to invalid beacon codes. The unit is capable of transmitting decimal digits, if desired by the pilot. These are used by private operators who have their own ground equipment. However, codes containing digits with values of 8 or 9 will not be recognized by NAS equipment, which uses only octal codes. Invalid codes will not be processed or displayed by the system. Also, the LOFF equipment in the airplane has only three digits available for a LOFF code while the ground equipment (EDARC) requires four digits in order to start a track. The solution implemented was for the converter to add a digit to the LOFF code and make it look like a conventional radar code to EDARC. This results in a discrepancy between the code input by the pilot and that displayed to the controller, which could lead to confusion.

Another issue to be addressed is the difference in the update interval code between newer and older LOFF interface units. The older units used a code of "1" to indicate that they were transmitting at a 15-second update rate. Newer units use this code to indicate a 7.5 second update rate. Since this code is transmitted as part of the LOFF message, the ground equipment checks the code and accepts only a "1." In order to operate within the system, a user with the latest model LOFF interface must set his update rate to 7.5 seconds. This results in alternate messages being discarded by the ground equipment and needless frequency congestion.

Although the system resembles radar in its appearance on the display, there are several important differences. The system as implemented does not include an identification (IDENT) function, which is available in the radar environment. This function is used to uniquely identify aircraft in the ATC system, especially as they enter the system. The nature of offshore operations involves a large amount of traffic which will climb into LOFF airspace from an oil rig or remote location. The system must have a means of identifying these aircraft.

Because of the differences between performance of LOFF and radar, the type of system in use should be somehow identified to the controller. The usual method in this type situation is to change the symbology of the target on the controllers display.

During simulation testing it was noticed that the tracker may cause the system to correlate the target's next position report over another stationary target. After both targets have been entered into the system as tracks, however, the system will correctly identify the targets and attach each to the appropriate track. Once the entire grid of simulated targets was entered into the system as tracked targets, it was very rare for the system to misidentify a track.

CONCLUSIONS

1. Conversion accuracy of the installed equipment does not meet the specified radar accuracy of 2 ACP's and 1/8 nautical miles (nmi) in all areas. However, the system performs consistently in a given local area. That is, aircraft near each other will be displayed at the proper separation. Local conversion effects are similar and should have little effect on aircraft separation. Stated differently, relative accuracy of the conversion is very good, although absolute

accuracy, as compared to existing radars, is much poorer. The effect of these errors is small relative to current radar separation standards.

2. End to end static and conversion accuracy data have been presented. They show that process results are very repeatable and regularly spaced for static targets. Tracker effects cause the displayed position to differ from the static position by 1.1 miles mean root sum of squares (rss).

LOFF target positions as computed by the Enhanced Direct Access Radar Channel (EDARC) show little or no variation in displayed position with altitude. Two targets at the same latitude/longitude (lat/long) but different altitudes will be displayed at the same position.

3. Coverage of the system using existing very high frequency (VHF) facilities varies from approximately 55 nmi at an altitude of 1000 feet to about 110 nmi at 5000 feet. Coverage of the area currently identified for Loran Offshore Flight Following (LOFF) use is, therefore, nearly total at altitudes as low as 1000 feet. This provides sufficient coverage for en route use. Procedures must be developed for granting Instrument Flight Rules (IFR) approach and departure clearances for operations to and from oil rigs which will involve operations below the LOFF coverage floor.

4. In areas of common coverage of LOFF and radar, radar should be used for separation purposes. Performance of LOFF in these areas was within 0.5 nmi mean rss of the radar position. The system should, therefore, enable controllers to perform ATC target handoffs for aircraft entering or leaving the LOFF sector. Radar track targets and LOFF track targets for the same aircraft will be very close to each other on the controller's display. Subjective assessment by the controller participating in the tests was that the display of these two targets in close proximity will not create a problem.

5. Performance of both Loran receivers in the area meets the requirements for en route accuracy established by existing standards. Accuracy of the ONI-7000 was excellent throughout the LOFF area. The TDL-711 was less accurate, but still within acceptable limits.

Based on Loran accuracy data collected during the flight test the exclusion area, as defined in the certification for the TDL-711 receiver, should be eliminated or reduced in size. Data to support this effort are being made available to the holder of the Supplemental Type Certificate.

6. The subjective evaluation by controllers was that system operational performance was nearly indistinguishable from that of radar. Differences in radar vs LOFF position were judged to be small enough that the presence of two targets for a single aircraft would not pose a problem. Also, the system was judged to be sufficiently reliable and accurate to enable handoffs to be made to or accepted from adjacent radar sectors.

Pilot response was also favorable. The system provides a service benefit and workload increase is negligible. The only detrimental aspect was the existence of the data burst in the cockpit headsets.

The system adds a requirement for maintenance and increased operational responsibility for facilities personnel. It is believed that the procedures for

initialization and operation of the system, which have been developed as a result of the tests, will prove suitable.

Overall results of the LOFF test program are favorable. The system performs in a predictable and reasonable manner. Performance of the system is comparable to that of radar, although there is a slight difference in accuracy between the two. The system performs well in the oceanic sector of the Houston Air Route Traffic Control Center and is compatible with the operational environment of the center. Once suitable separation and certification criteria have been established the system should be certified and used to provide separation assurance in the offshore area of the Gulf of Mexico. There is no technical reason to delay the further development of Loran Offshore Flight Following for use as an air traffic control tool.

RECOMMENDATIONS

In order to fully implement the Loran Offshore Flight Following (LOFF) system for control purposes several issues must be resolved. These are described briefly below.

1. Separation standards must be developed which take into consideration the special needs of offshore operators and the capabilities of the installed equipment.

2. Procedures must be developed for use by controllers and pilots to provide clearance and conduct approaches and departures from oil rigs below the LOFF coverage floor under Instrument Flight Rules (IFR) conditions.

3. Standards must be developed in order to provide for airborne equipment certification.

4. Further study should be made into improving the integrity of the data link. Improvements may include increasing the number of offshore very high frequency (VHF) frequencies available, or modifying the operation of the data link to reduce the amount of interference (i.e., voice or other aircraft data) on the channel. Possible solutions of this type include adding ground equipment to interrogate the avionics, or to synchronize the transmission of LOFF data messages. System modifications of this type should attempt to minimize the changes required for existing avionics.